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The Future of Transportation

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INTRODUCTION

Getting from here to there in the United States today can feel a lot closer to an episode of *The Flintstones* than *The Jetsons*. Every day we deal with problems that should be relics of the past: congested highways full of single-occupancy cars, mass transit systems continually under threat of service cuts, and aging infrastructure on the verge of obsolescence if not total collapse. For all humanity's advances, our daily haul can still be a nightmarish experience that reduces productivity, increases stress, endangers public safety, and hastens global climate change.

Fortunately, the future is not all bleak. The flipside of these challenges is a bounty of ideas for how to improve travel in and around America's cities. We're recognizing the limits of our current highway systems, finding ways to increase transit efficiency and expand its development, and preparing for the not-so-distant day when our cars will drive themselves (and our "smart" streets will guide them). For every commuting obstacle we face there's a brighter dream of better mobility.

In a nine-month special series called *The Future of Transportation*, which ran from February to October 2014, *CityLab* explored the initiatives and technologies being developed right now that will change the way people travel around cities in the years to come. Our team of writers reported from every big metro area across the country, while mobility experts and local officials shared thoughts and lessons that can apply to cities of all sizes. In both a physical and intellectual sense, we covered a lot of ground.

This e-book includes a dozen of our favorite stories from the series: three from each of its main parts (commuting, sustainability, and design), and three companion policy pieces. While it was impossible to choose every great moment, these selections

reflect both the geographic and multimodal reach of the series, taking readers across the country on roads, rails, and runways. The articles have been copyedited slightly since their original publication for clarity and consistency, and any factual corrections have been made to the text.

Support for this series and this e-book came from [The Rockefeller Foundation](#), whose mission for more than 100 years has been to advance a more resilient and equitable world. It's our view that there may be no better way to achieve those goals than affordable, reliable transportation, and we thank The Rockefeller Foundation for their deep understanding and commitment to this issue.

And rest assured our regular *CityLab* coverage will extend and expand on the themes we discussed in this series. The journey continues.

Eric Jaffe
Series Editor

PART 1

THE PERFECT COMMUTE

New and better ways to enhance the journey to and from work.

Chicago's Big Bet on the Bus



COURTESY CTA

The Ashland BRT line has become a referendum on the city's evolution.

MATT DELLINGER | *Originally published February 27, 2014*

CHICAGO—Just 10 years ago, living in Chicago without an automobile was considered eccentric behavior. In 2002, a food-writer friend moved there from New York and bravely attempted to get by using public transportation, taxis, and her own feet. Her colleagues at the *Tribune* thought her quite mad, and assigned her pieces in the suburbs (“part of my hazing,” she says). Being from Indianapolis, I often described Chicago as what would happen if my hometown and New York had a baby: Chicago is midwestern but urbane, approachable but grand—and somehow both car-oriented and transit-friendly.

Ten years has made a lot of difference. We now live in the age of bike-share and car-share, and today Chicago attracts plenty of people, mostly young and single, who would probably rather carry a flip phone than own a car. Yet the late 20th century remains baked into the city's landscape—there are

drive-through banks a 10-minute walk from Michigan Avenue downtown, and big-box stores and a strip mall with suburban-sized parking lots around the corner from the Steppenwolf Theatre.

Chicago's transportation split personality explains a great deal about how its recent plan for [bus rapid transit](#) (BRT) along Ashland Avenue [could become controversial](#). And it has. In January, I met separately with opponents and supporters of the proposal, and both sides used the word *transformational* to describe the city's BRT plan. One side meant it as a compliment, the other as a slur. As cities across the country [debate the merits](#) of sacrificing car lanes for mass transit, many eyes are on the midwestern metropolis, where a proposal touted as a sensible way to improve commutes has become a referendum on how drastically the city should evolve.

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Ashland Avenue is one of Chicago's few continuous north-south thoroughfares, and its virtues as a transportation corridor have a lot to do with both its continuity and its position in the city. Thanks to the curve of the lakeshore, the avenue runs as close to downtown as a north-south arterial can while also reaching the northern neighborhoods, which happen to be, on the whole, the most affluent on the Ashland corridor. It intersects with seven Chicago Transit Authority "L" stations, two regional Metra stations, and 37 bus routes.

The planned 16-mile Ashland BRT route would affect a cross-section of Chicago that contains all of the city's ethnicities, income levels, and zoning types. It slices through neighborhoods that are Polish, Mexican, African American, and white. It cuts through retail, residential, and industrial areas. The current buses on Ashland carry more than 30,000 people every day, and they go very, very slowly: [about 8.7 miles per hour](#).

In 2012, shortly after Rahm Emanuel was elected mayor, he and then-Chicago DOT Commissioner Gabe Klein [got to work](#) on a progressive transportation agenda that aimed to create 100 miles of protected bike lanes, a number of rail improvements, and a trio of BRT lines. (Here's where I should note that Klein told me that the Rockefeller Foundation, which provided support for this article, contributed \$2 million in grants to advocate for Chicago BRT.) The first BRT line, known as the [Jeffery Jump](#), has already begun

daily service, running from the Loop downtown via Jeffrey Avenue to 103rd Street on the South Side. The second BRT line will run along [two east-west streets](#) in the Central Loop; construction on this Loop BRT line, which has not been particularly controversial, is scheduled to begin this spring.

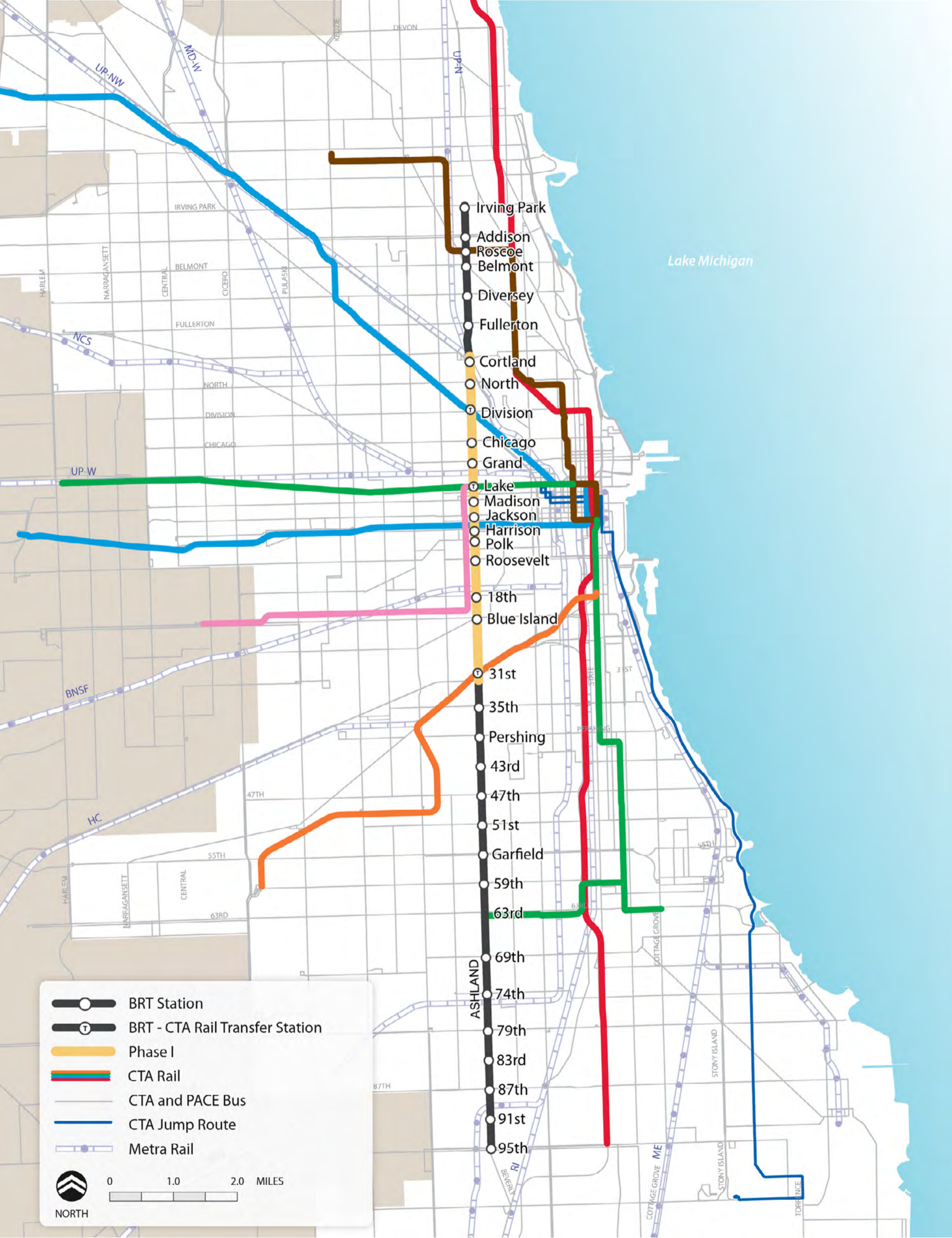
Ashland is the third line, and its planning began in 2012. A north-south transit corridor near Ashland had been studied for years as a way of connecting the L lines so commuters could move between corners of the city without passing through downtown. Not long ago, the plan was for a [new rail link](#), the Circle Line, which would have required new subway and elevated track at a cost of more than \$1 billion dollars. In the face of federal budget battles and cuts, such a figure could prove an insurmountable obstacle, and BRT has become popular among transportation planners and advocates because its dedicated lanes, traffic-signal priority, and prepayment system mimic the benefits of rail at a fraction of the cost. The Ashland BRT line is estimated to cost \$160 million, or \$10 million a mile.

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When you rule out subways and elevated trains, public transit must run on the streets, and in the case of Ashland, this means giving half of local roadway capacity to BRT buses. In the preferred design alternative chosen by the city, car and truck traffic would be limited to one lane in each direction. And while the stations for the Jeffery Jump and Loop BRT lines are curbside, the Ashland buses would run in the center of the road, with stations in the median—eliminating left-hand turns. (Many of the proponents I spoke with believe the final design will [restore left turns](#) onto major east-west arterials, however.)

This dramatic reshaping of Ashland is a bit scary for some. Roger Romaneli, executive director of the Randolph/Fulton Market Association, an organization of local businesses, has led the charge against the BRT proposal. “Ashland is an industrial corridor with 700 businesses throughout,” he said. “They invested in our corridor because they had reasonable expectation that Ashland would run the way it does today.”

Indeed, Ashland in the central city has more than its fair share of auto-body garages, and the street is thick with parking lots and drivethroughs



BRT Station

BRT - CTA Rail Transfer Station

Phase I

CTA Rail

CTA and PACE Bus

CTA Jump Route

Metra Rail

0 1.0 2.0 MILES

NORTH

belonging to businesses that clearly cater to drivers. Representatives from a number of these, including a new Costco, came to public meetings in December [to speak out](#) against the BRT plan. “You don’t go to Costco in a bus,” the store’s general manager told the *Sun-Times*.

Romanelli’s criticism of the BRT plan is made more compelling by the fact that in the past he’s often advocated for better transit access. “I’d been working as an economic-development practitioner for years. We’ve been pro-transit-oriented development, and pro-bus service,” he said. “We helped bring express buses to Ashland, and a new L station at Morgan and Lake.”

Romanelli’s group has put forward an alternative plan for improving the corridor’s bus service. The [Modern Ashland Bus](#) plan maintains the open traffic lanes for cars while implementing a number of the features of BRT. He thinks those improvements should be instituted across Chicago. “We want to revolutionize bus service around the city,” he said. “If we can do it on Ashland Avenue—heated bus shelters, streamlined stops, signal priority—we can do it throughout the city. The current bus service in this city is substandard.”

Suzi Wahl, a neighborhood resident who works at Chicago O’Hare International Airport, joined our meeting as well. Her main concerns were not in-

dustrial in nature, but residential. When you take away Ashland as a driving arterial, she worries, thwarted through-traffic will inevitably divert to the smaller streets nearby, such as her own. “I see this as destroying the neighborhood,” she said.

**“I see this as
destroying the
neighborhood.”**



Wahl too has good transportation credentials: she takes the bus routinely, and she used to participate in [Critical Mass](#) bike rides intended to “take back the streets of our city” and remind people of the right to assemble. (She stopped riding after she became pregnant.) One night in October of 2013, while canvassing businesses on behalf of BRT opponents, Wahl felt a pain in her stomach and went to the emergency room at the University of Illinois Medical Center on Ashland. She was fine, but the adventure highlighted what she sees as a major drawback of removing traffic lanes and increasing congestion.

“If that was post-BRT, I’d have my husband driving in the BRT lane. If that was my daughter, I’d be driving on the sidewalk,” she said. “A bus to the ER? Are you kidding?”

The medical center’s administrators, meanwhile, have come out in support of the BRT plan, saying it would enhance access for employees and patients. But Romanelli and Wahl note that the medical center also happens to be a major landholder and could stand to benefit from development opportunities along the BRT line. They point to an [online map tool](#) created by the Metropolitan Planning Council—showing zoning, vacancies, and median income along Ashland—as proof that some advocates have their eye on more than just faster buses.

“Is the BRT also a Trojan horse for developers? To skyrocket taxes on Ashland Avenue, take these buildings from these family-owned businesses who are struggling while minimalls are being constructed in our city?,” Romanelli mused. “Is this transit improvement, or is this a forced gentrification project?”

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Chris Ziemann, project manager for Chicago BRT, freely admits that redevelopment is a secondary goal. The primary goal, he says, is to help buses run faster and continue Chicago’s transition toward what’s known as [“complete streets.”](#) “The more transformative a project is, the less easy it goes down. And Ashland is extremely transformative,” he says. “But there’s growth pressure on the corridor anyway. We see car ownership decreasing. So this is to respond to those future trends. This is transformative because it needs to be.”

Ziemann had organized a lunch with a handful of supporters at a Polish restaurant near Division and Ashland, and over blintzes and sausages, the group tried to make the case for the BRT, unafraid to describe the future Chicago they envisioned and the bold action required to facilitate it.

Burt Klein, a board member of the Industrial Council of Nearwest Chicago, an organization not unlike Romanelli’s local-business association, admitted that his board colleagues were starkly divided on the issue of the Ashland



Chicago BRT enthusiasts at the "BeeRT pub stroll" last October. STEVEN VANCE / FLICKR

BRT line. But he dismissed the arguments against the project as coming from a knee-jerk fear of change. "I don't think they have a vision of the future," he said during the lunch. "I drive my car, therefore I want car lanes.' It's not people who don't own cars. It's the view that roads are made for cars. They're upset about bike lanes. Upset about bus rapid transit."

Brenna Conway, the transit campaign coordinator for the Active Transportation Alliance, pointed out that a quarter of households along the Ashland corridor were carless. "And I imagine many more are families that have just one car," she said. "A significant number of people live here and are already dependent on transit."

"I think there's something else," added Klein, "which is all of these cities are competing for young people. And you compete for young people because if you grab them when they're young, they end up settling in the area. And that's how cities stay vibrant. Again, the younger generation is looking for livability. They're not looking for a way to drive."

“We understand that people have gotten used to things. But that doesn’t make them good, you know?” said Conway. “You can’t not do something because it might be uncomfortable.”

As agreed as the group was about the need for BRT, when I asked those around the table if there was anything they would change about the project, they all had peeves.

Anna Shibrowsky, a copywriter who works at home and spends much of her break time commenting on transportation blogs, said she would remove the parking from Ashland and replace it with protected bike lanes. Conway and Michael Whalen, a student at the University of Illinois at Chicago studying urban planning, both said they’d prefer the city tackle the entire 16-mile route at once rather than phase the construction. Klein ad-

mitted that his industrial group was concerned about doing away with left turns, and the effect it might have on truck access.

“You can’t not do something because it might be uncomfortable.”

“But really I only care about one left turn,” he said, referring to one near his company’s office. Everyone at the table laughed. “I make a joke of it, but that’s what matters to us.” He expected that his left turn would be restored in the final design phases, and he hoped the


city would move quickly to finish the project. “I look at Ashland, and this is already five-to-10 years late,” Klein said. “By the time it’s built, Western [Avenue] will be overdue for BRT.”

As we walked out of the Polish restaurant, Ziemann showed off the recently completed [11-story residential tower](#) on the corner of Division and Ashland. He said it had replaced a boarded-up Pizza Hut and its parking lot. There were 99 units in the new building, yet no resident parking. Before this building was approved, a developer had come forward with a proposal for an apartment tower with a drive-through bank on the ground floor, but the neighborhood association [nixed the idea](#). It would have brought too many cars to the area.

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Almost everyone agrees that the fate of the embattled Ashland BRT line will be decided in February 2015, when Rahm Emanuel is reelected, or not. The mayor has been quiet about the plan lately, but proponents have faith that he'll see the new line through if he holds the mayor's office.

Romanelli is wise to this reality. "There are some lawyers involved," he says, who are looking at whether the city's environmental assessment of the project (which stated that it would have [positive impacts](#) on air quality and economic development, among other factors) might be worth challenging in court, "but really we're looking at a pure political mobilization." Romanelli is targeting local officials along Ashland, several of whom have come out publicly with concerns about the BRT's transformative nature.

If it were up to Gabe Klein, the former DOT chief, the city would fly some of the critics to a city where BRT is already working. This winter, Klein says, he went to Nantes, France, and rode the BRT there. "It's amazing. I'm a huge advocate for BRT, but even I need to ride it to be reminded how amazing it can be," he said. "People in Nantes can't imagine the city without it. Just like most Americans—most people—can't imagine something they haven't seen before." 

Putting a Price on D.C.'s Worst Commute

I-95 south of the nation's capital has some of the worst traffic in the country. Soon you'll be able to buy your way out of it.



[RAFAL OLKIS/SHUTTERSTOCK.COM](https://www.shutterstock.com/rafalolkis)

EARL SWIFT | *Originally published March 18, 2014*

WASHINGTON—For a few giddy moments, it seems I've dodged the torture awaiting commuters heading into Washington, D.C., most any weekday morning. As I merge onto Interstate 95 in Fredericksburg, Virginia, 50 miles from the Pentagon, the traffic around me glides along at the 65-mph speed limit. No brake lights illuminate the predawn dark. I set my cruise control. Perhaps, I dare to think, this won't be so bad.

The illusion ends before I've covered a mile. Without warning or obvious reason, the highway's flow thickens to a viscous dribble. My speed drops to 30, then 15, then an idling roll slower than I can walk. It remains there for a minute before shuddering to zero. I sit.

It's 6:30 a.m. on a typical Monday on the outskirts of the nation's capital, and I'm mired in traffic the [Texas A&M Transportation Institute](#) reckons to be the worst in America, trumping even the titanic freeway logjams of Los Angeles. Here are highways so notoriously overtaxed that even on weekends, "speed" is more a lovely abstraction than a realistic goal. Here is a circumferential interstate—the famed Washington Beltway—that has become synonymous with stress.

Of all Washington's snarled roads, perhaps none is more feared, despised, and lamented than the roughly 41 miles of I-95 between Fredericksburg and the Beltway, and I-395's nine-mile spur from there to the Potomac. It's a journey that should take under an hour but typically takes two or more in the morning. And in the evening, half again as long.

My Camry inches northward, the sky lightening to a leaden gray, the air stinking of overheated brakes. For two generations, Virginia transportation officials have battled the route's glacial pace with a succession of innovative prescriptions. In 1969, they installed the first reversible bus lanes in America, on I-395. A few years later they turned them into carpool lanes—the country's first courtship with high-occupancy-vehicle lanes. Later they extended HOV 18 miles south, into the fast-rising suburbs and exurbs straddling I-95.

The route remains a quagmire, just the same. So now the state is embarking on another fix. With financing from private investors, Virginia is converting the HOV lanes south of Washington to high-occupancy toll lanes, or HOT lanes. These express lanes, like [20-some similar projects](#) in cities from coast to coast, will enable solo motorists to drive alongside carpoolers—for a price.

If the new system works as the Virginia Department of Transportation hopes, it will cull a fat number of commuters from I-95's general-purpose lanes and speed the trip for everyone. The private investors may earn

enough in tolls to retire their debts and make some money to boot. But the new arrangement differs from those already in place elsewhere, and with the differences come questions about how much relief it can offer. Some won't be resolved until the new lanes are up and running in early 2015.

All of which is to say that we're soon to witness a complex and very expensive experiment.

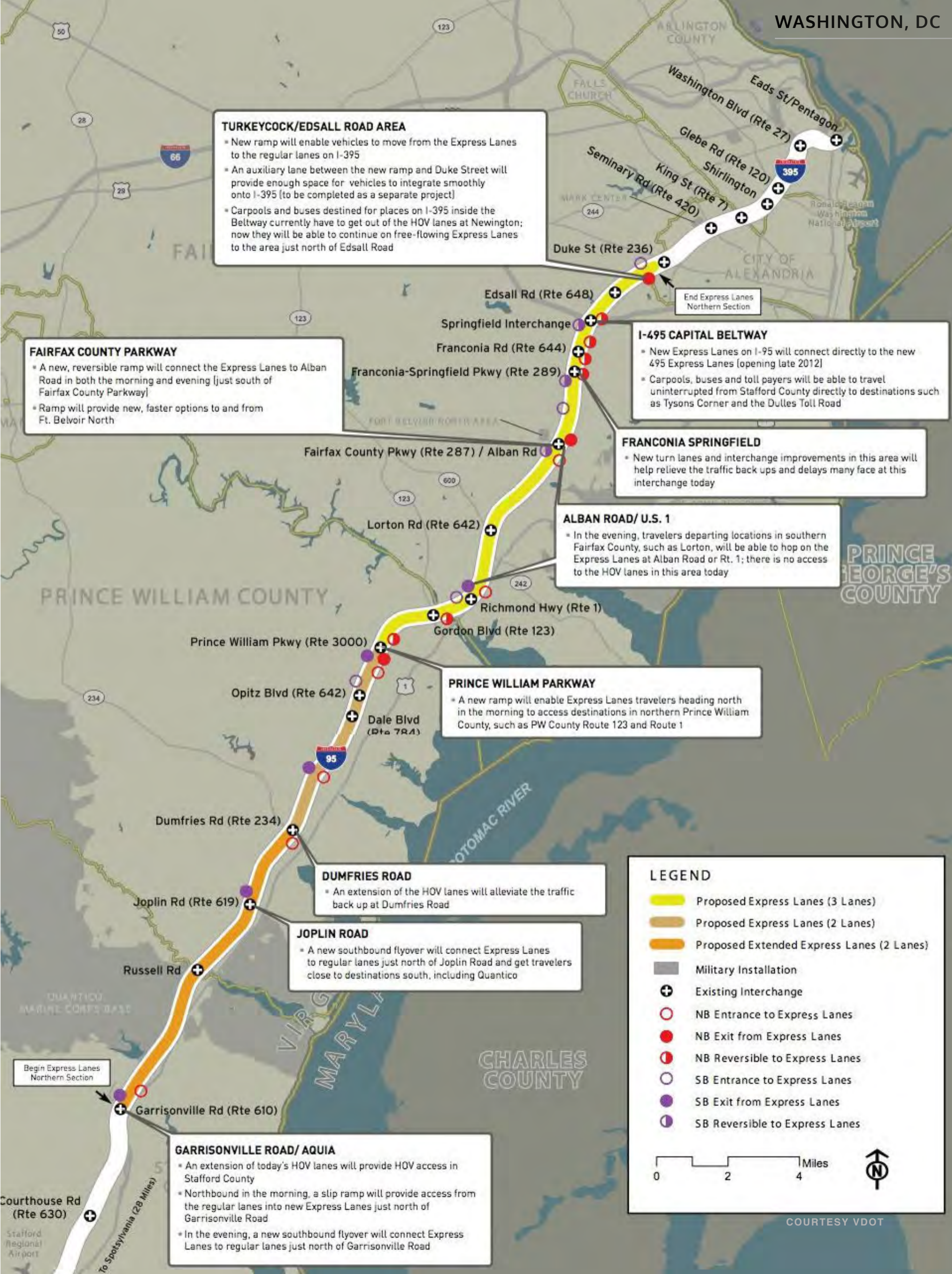
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The rush-hour nightmare in Northern Virginia is partly the product of topography. Geographic obstructions funnel travel into a narrow corridor occupied by I-95 and its smaller and equally congested parent, U.S. 1, and little else. It's also partly the product of Northern Virginia real estate, which rises in price as distance from the District (and the exasperations of the daily commute) falls. Not many years ago, the 50-some miles to Fredericksburg was an inconceivable distance for daily commuting; not so today, and the suburbs continue to spread like a stain, pushing farther south and west every year.

V_{DOT}'s attempts to address the corridor's congestion by siphoning traffic from the general-purpose lanes have succeeded, at least in part. The bus lanes proved a hit 45 years ago—a *Washington Post* [rush-hour race](#) into the District saw a bus beat a car by 32 minutes, and before long bus commuters outnumbered their automotive counterparts on I-395. Likewise, the HOV lanes have consistently moved more people than the regular lanes at rush hour, according to V_{DOT}. In fact, says the agency, they're the most successful HOV lanes in the country.

Be that as it may, the lanes are underused. As I sit immobile in my Camry in Dumfries, where the HOV lanes now have their southern terminus—and where an electronic sign predicts that I won't reach the Beltway for another 52 minutes—the procession of cars entering the faster lanes amounts to a slim rivulet leaving the interstate's main flow.

So the state partnered with a [joint venture](#) of two private firms—the Texas-based Fluor Corporation and an Australian toll-road outfit, Transurban Group—to convert the existing I-95 HOV lanes to accept toll-paying custom-



ers, and to extend them into Stafford County, Virginia, 27 miles south of the Beltway. As originally planned, the reversible HOT lanes would continue inside the Beltway in the median of I-395 to the District's very edge: the 14th Street Bridge, where the highway crosses the Potomac. Drivers using the lanes would enjoy a high-speed shot from the far-flung suburbs all the way into town.

In fact, they're all but guaranteed that. A key part of the [\\$922.6 million deal](#)—under which the state will supply \$82.6 million of the project's cost, and Fluor-Transurban will pony up the balance in cash and debt—is that the HOT lanes will keep flowing at 55 mph.

Fluor-Transurban, which will recoup its investment through the toll income it generates over 76 years, will maintain that flow through dynamic pricing, which makes a commodity of a commuter's time. "There is a value to a less-congested lane that someone driving alone might be willing to pay for," says Philip Shucet, a Norfolk-based consultant who led VDOT as the agreement took shape. "Congestion creates a demand for a freer-flowing lane; therefore, because of the demand, you can charge for the supply of that lane."

Fifty minutes into my journey, traffic in I-95's general-purpose lanes chugs along at 15 mph. HOV traffic, a blur to my left, shares the median with towering heaps of dirt and earth-moving gear. Construction of the new HOT lanes is nearly 70 percent complete, according to Fluor-Transurban, and on schedule for an early-2015 opening.

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A taste of what motorists can expect is already available in the capital region, for the I-95 project is the second phase of two in the state's partnership with Fluor-Transurban. The first was the installation of HOT lanes on a [14-mile stretch](#) of the Beltway's curving western side, from its junction with I-95 north to just past the Dulles Toll Road. Portions of the highway now shoulder nearly a quarter-million vehicles a day.

The 495 Express Lanes, as they're officially called, opened in November 2012 after four years of construction. They cost [\\$2.07 billion](#), according to



Renderings of traffic flows on the I-95 Express Lanes. VIA [TRANSURBAN OPERATIONS INC](https://www.transurban.com/)

the Federal Highway Administration, which covered the replacement of more than 50 bridges and overpasses and the creation of several new HOT-only entry and exit points. The [public-private pact](#) is structured much like that for I-95: in exchange for covering most of the bill (\$349 million in cash, plus debt service on more than \$1 billion in loans and bonds), Fluor-Transurban will operate the lanes for the coming 74 years, after which they revert to the state.

“VDOT owns the road,” says Transurban spokesman Mike McGurk. “We’re essentially just renting.”

The Beltway lanes are not reversible. Rather, two in each direction are separated from the general-purpose lanes by a line of flexible pylons and linked to exits by dedicated ramps. When I entered them on a weekday midmorning in early March, the whole northbound trip cost \$6.75; reaching the I-66 interchange would set me back \$3.35, and the edge city of Tysons Corner, \$5.05.

Those prices struck me as steep until I buzzed past stacking traffic in the regular lanes at Annandale, a denser clog at I-66, and a mile-long clot at Tysons Corner. The Camry was making a steady 72 mph. I covered the 14 miles in under 14 minutes, which was downright surreal on that road at that time of day.

When I headed the other way, against the traffic, the toll was \$2.55 all the way to the Springfield Interchange, where the Beltway meets I-95 and the I-395 spur into town. I didn't have to hunt for change. Both Virginia projects are designed to accept only electronic payment, through a transponder affixed to each vehicle's windshield. Those motorists who travel alone can use a [regular E-ZPass](#), and those who carpool, an E-ZPass Flex.

The Flex model features a switch that converts the unit from toll-paying to HOV operation. When a driver enters the HOT lanes toting fewer than two passengers, the Flex unit operates as a standard E-ZPass. But drivers that qualify for HOV status merely need flip a switch on the box, excusing the car from the toll. As the vehicle approaches the HOT lanes, an electronic receiver will detect the transponder's HOV setting and alert a Virginia state trooper posted nearby (and paid for by the partnership) to eyeball the passing vehicle to ensure that it's playing by the rules.

"They also have technology in their cars that can communicate with the infrastructure," says McGurk of the troopers. "So even if they're traveling behind a car, they'll know whether that car has identified itself as an HOV vehicle."


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Now for the questions, the first being: Will the I-95 HOT lanes attract a sufficient number of non-HOV users to make a dent in the traffic? So far the Beltway lanes have not enticed the number of motorists, or generated the level of revenues, that [the partners expected](#). In 2013, Transurban figured it would take in \$60.2 million; revenues actually totaled less than a third of that amount (\$17.2 million). Weekday use was expected to reach 66,000 trips by year's end; reality delivered about 38,000.

This is in keeping with the early performance of HOT lanes in [other U.S. metro areas](#). Revenues have disappointed in Atlanta, Houston, and Seattle. McGurk blames the [novelty of the experience](#). "It's the first time D.C. has ever seen dynamic tolling, and an E-ZPass requirement," he says. "There's some education left to do. There are still a significant number of drivers out there who do not have an E-ZPass. It's taking some time for people to understand how to take advantage."

Even so, says McGurk, “there are good trends.” Toll income rose 18 percent from the second quarter to the third of 2013, and by another 24.2 percent by year’s end, despite a flattening in the number of trips in the lanes late in the year. Usage jumped by more than 60 percent over the first year of operation, he says, and Transurban has “heard great feedback from customers who take the route.” The consortium, which recently refinanced its obligations, anticipates “consistent growth.”

So far Beltway HOT lanes have not enticed the number of motorists, or generated the level of revenues, the partners expected.



An important lesson is that “people tend to use it episodically, rather than all the time,” says J. Douglas Koelemay, director of Virginia’s Office of Transportation Public-Private Partnerships. “The morning they have that early meeting, it’s important for them to move quickly, and they’re happy to pay the toll. On other days, when they’re not in such a hurry, maybe they don’t mind taking longer.” Fluor-Transurban “recognizes that it’s building a long-term business,” says Koelemay, noting that the consortium has refinanced the venture.

There are other broad questions—including the ongoing debate about whether or not HOT lanes are [fair to low-income drivers](#)—but in the case of the I-95 project, there’s one especially vexing worry. As a result of a legal standoff with Arlington County, the I-95 HOT lanes will now extend [only 29 miles](#), to just inside the Beltway, instead of stretching 36 miles and taking commuters all the way from the exurbs to the Potomac. At this abrupt end point, the interstate’s express lanes will become HOV-only. Toll-paying motorists will be dumped back into the general population.

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By the time I reach the Springfield Interchange, I’ve been on the road for 61 minutes. Just after sunup I slip beneath an overpass marking the first exit on I-395, at Edsall Road. Up ahead, crews are already at work in the median on the primer-painted bones of a massive flyover, which arcs from the fu-

ture HOT lanes, curves over northbound I-395, and swoops down to merge into the freeway's slow lane. This is the Turkeycock flyover, the northern terminus of the HOT lanes project. Here, seven miles shy of the Potomac, toll-paying commuters will be forced to leave their carpooling fellow travelers to rejoin 395's stop-and-start traffic.



Construction of the I-495 Express Lanes near Tysons Corner. VIA [FLUOR](#)

What will happen? Will monolithic jams erupt as the merging traffic re-enters the mainstream? Does the project merely relocate and compress the morning nightmare? Will commuters, recognizing that the HOT lanes offer them an express ride to gridlock, forgo the toll route altogether?

“I don’t know how that’s going to work,” says Mark Dudenhefer, a former state delegate from Stafford County who suffers the I-95 commute every weekday. “How would you like to be the guy who pays whatever the toll is—

from, say, \$5 to \$15—and you don't get to where you need to go? You get forced back into the regular lanes, and you have bumper-to-bumper commuter traffic. What have you really saved? It's difficult to understand."

This is no idle worry, for the I-395 leg of the commute is often the toughest, as I find during my excursion. It takes me 23 minutes to cover the less than three miles from the Turkeycock flyover to the Arlington County line, which I cross at 2 mph. It takes another 18 minutes to traverse the roughly four miles to the Pentagon's southwest corner, looming off to the highway's left. Another five minutes moves me half the length of the building's south wall.

The partners forged on, says Steve Titunik, a VDOT spokesman, because commuting times should nonetheless fall. The surviving mileage includes a new general-purpose lane and dedicated HOT-lane ramps at one busy cross street that should loosen the knot on I-395. Dudenhefer, who says he was involved in the project's early stages as a county supervisor, says holding out for a perfect solution could leave everyone in the same place 15 years from now.

"I don't think we could afford to wait," he says.

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This thing could go any number of ways. It could spawn new and fearsome jams on I-395, choking Arlington County with the exhaust of idling legions of cars. It could provide an improvement over the current, wearying daily grind. It could convince commuters who've shied away from carpooling


that the HOV lanes are the only practical way to get a car into D.C. The HOT lanes could be so popular, and inspire so fierce a public demand for their extension to the Potomac, that talks between state and county resume.

Fact is, there's no telling what will happen, which makes the 95 Express Lanes' opening in 10 or 11 months an occasion worth watching. J. Douglas Koelemay figures the truncated

"Urban areas are never finished. They're always changing."

project, while “not the final or most elegant solution,” is “in itself important.” It’ll bring some relief, he predicts. “And it does not preclude our coming to an agreement with Arlington to go into Arlington or through Arlington. If you do it in a way that doesn’t diminish your opportunity to get to the next piece, I think you’re OK.

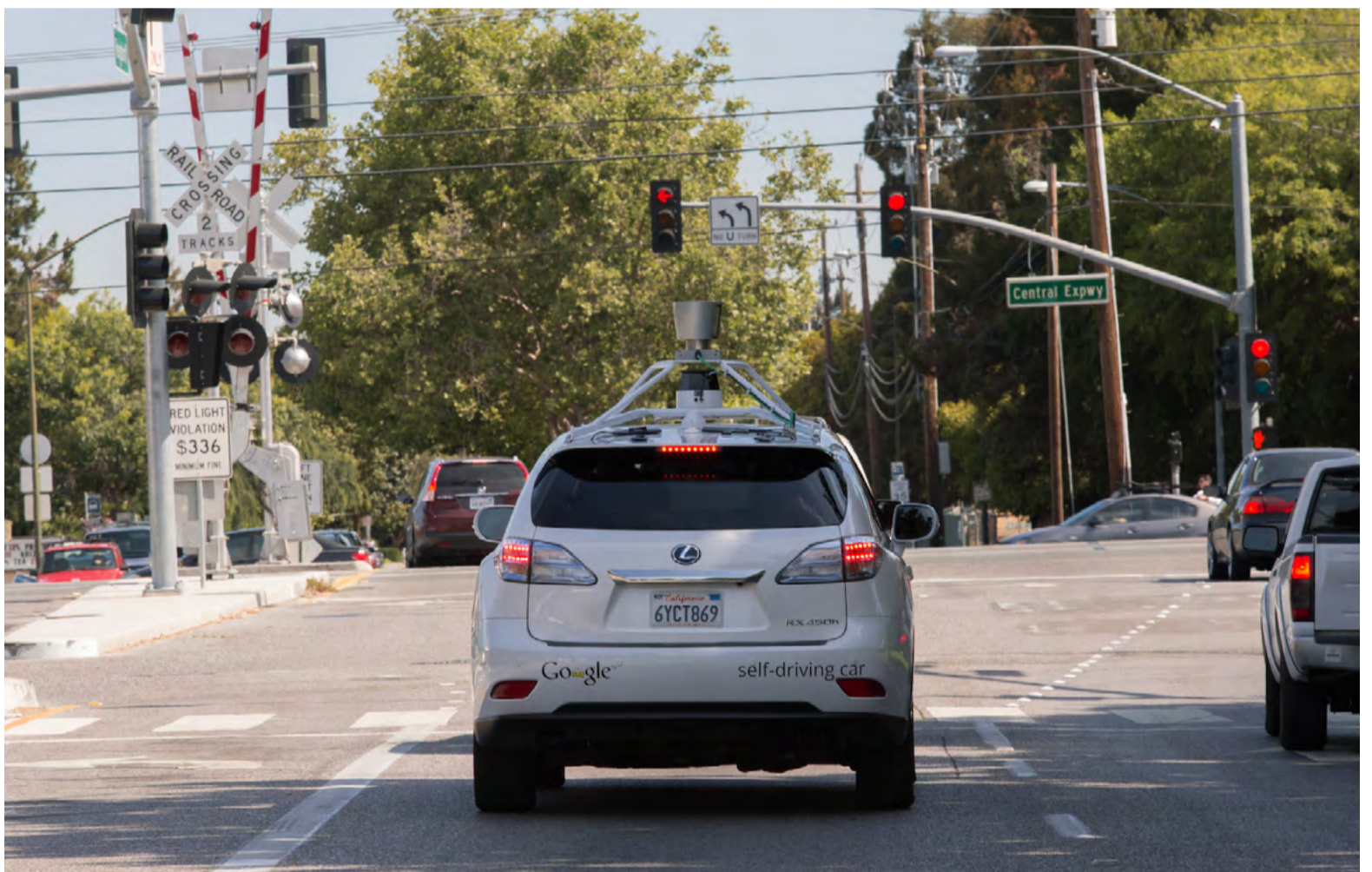
“Urban areas are never finished,” he says. “They’re always changing.”

In the short term, some commuters may be satisfied by any tonic to their daily pain, no matter how mild. My experiment ends at 8:35 a.m., when I pull off I-395 just shy of the river and meander my way to Reagan National Airport. I have spent 125 minutes in the car. I have driven exactly 50 miles. By current standards, that’s not a particularly bad start to the day. 

The First Look at How Google's Self-Driving Car Handles City Streets

The vehicle has now moved beyond highways to its next phase: roaming the roads of Mountain View.

ERIC JAFFE | *Originally published April 28, 2014*



GOOGLE

MOUNTAIN VIEW, Calif.—The first rule of riding in Google's self-driving car, says Dmitri Dolgov, is to not compliment Google's self-driving car. We've been cruising the streets of Mountain View for about 10 minutes. Dolgov, the car's software lead, is sitting shotgun. Brian Torcellini, the project's lead test driver (read: "driver"), is sitting behind the wheel (yes, there is a wheel). He is doing no more to guide the vehicle than I'm doing from the backseat. I have just announced that so far the trip has been "amazingly smooth."

“The car knows,” says Dolgov.

He means I have violated some robotic superstition, calling the contest too early. Or maybe he means my praise serves no function here. If I can tell how well the car is driving itself, so can the car.

Google’s self-driving-car project began in 2009. The vehicle’s early life was confined almost entirely to California highways. Hundreds of thousands of test miles later, the car more or less has mastered the art—rather, the computer science—of staying in its lane and keeping its speed. So about a year and a half ago, Google’s [team shifted focus](#) from the predictable sweep of freeways to the unpredictable maze of city streets. I was invited along as the first journalist to witness how the car is handling its new urban lifestyle.

Over the next few minutes, the autonomous vehicle makes several maneuvers that someone not privy to Dolgov’s first rule would have been tempted to compliment. We go through a yellow light, the car having calculated in a fraction of a second that stopping would have been more dangerous. We push past a nearby car waiting to merge into our lane, because our vehicle’s computer knows we have the right-of-way. We change into the right lane for seemingly no reason until, a minute later, the car signals a right turn. We go the exact speed limit because maps that the car consults tell it this road’s exact speed limit. The car identifies orange cones in the shoulder and we drift laterally in our lane, to give any road workers more space.

Between you and me: amazingly smooth.

Equally amazing is that people around us are going about their daily lives. I’d read that drivers [tend to gawk](#) at the Google car from their own cars, but that is not the case today. At one intersection I look at the cars flanking us. The driver to our right finds her cellphone more fascinating than us; the driver to our left is resting his head in his palm, and may or may not be falling asleep. There is a banality to vehicle autonomy in this place.

It can’t be that they’ve missed us. If the spinning bucket suspended by four metal arms on the roof doesn’t give us away, the words *Self-Driving Car* on the rear bumper should. We’re in a white Lexus RX 450h, part of a fleet of about two-dozen prototypes, all of which now spend most of their time on

surface streets. The bucket spins 10 times a second, emitting 64 lasers that generate 3-D information on objects all around us; the car also has radar that bounces 150 meters or so in every direction to perceive things a human driver never could. The Lexus's interior is standard with the following exceptions: a camera facing out from the windshield capable of reading traffic lights, street signs, etc.; an on/off button on the steering wheel to engage or disengage autonomous mode; a driver's side display panel showing our speed and position; and a big red button on the wooden console—a kill switch the team has never had to use.

“Every robot has a big red button,” says Dolgov.

Dolgov is holding a laptop running a map that effectively displays what the car is “seeing.” There is a comment box on the screen where he can record notes should something of interest occur during the ride. Right now he is not recording any notes. “Not much interesting stuff is happening,” he says. I had actually been promised ahead of time that “interesting things” would happen during the ride, so I could feel a bit misled at this moment. Except I’m riding in a car *that’s driving itself through a city so amazingly smoothly that people around us are falling asleep.*

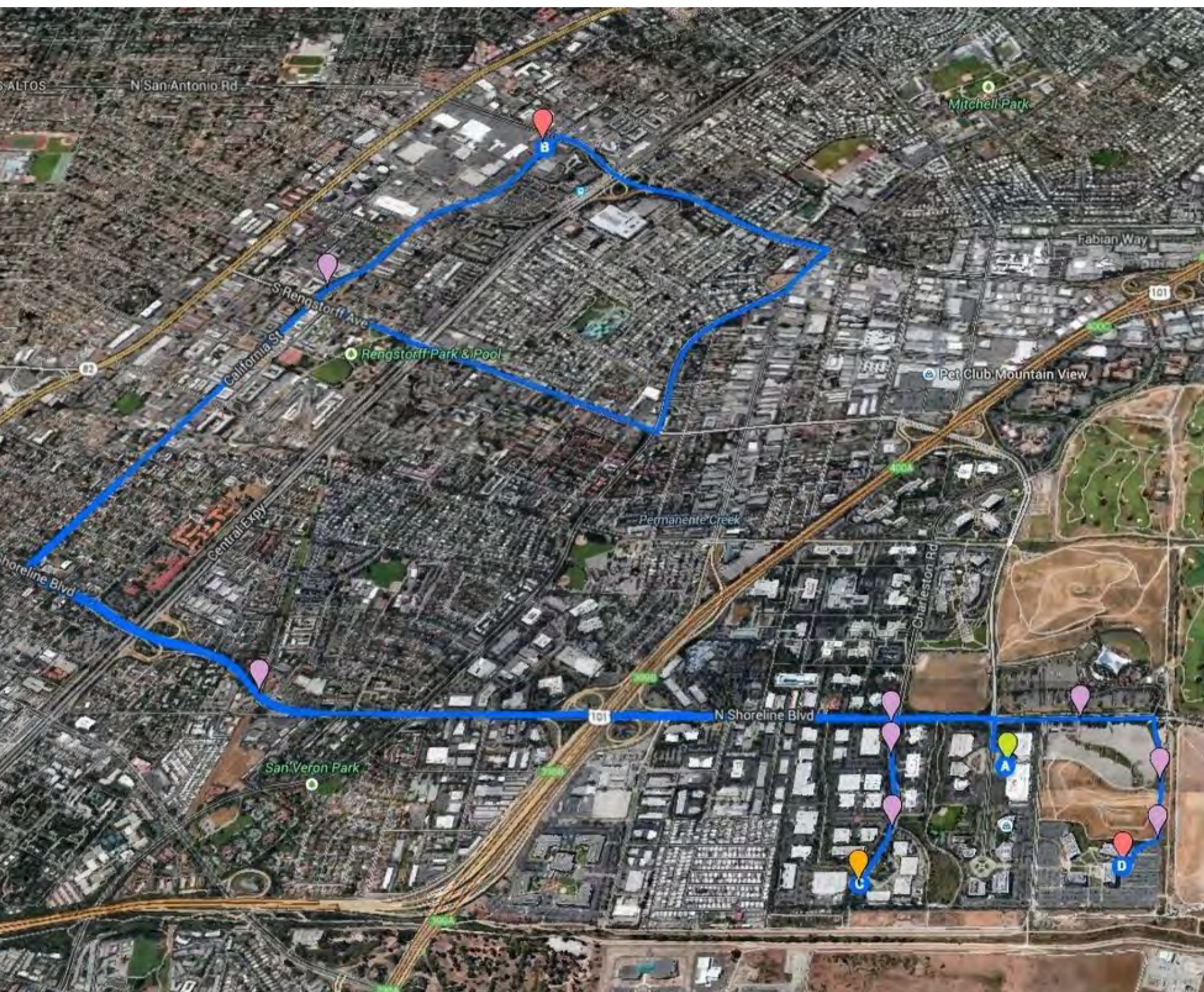
In that sense this uninteresting ride feels profoundly, even unimaginably, interesting.

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The head of Google’s self-driving car project is Chris Urmson, a tall man with tousled blond hair and a boyish grin to match an idealistic spirit. We met at a Google X building just before my test ride. Google X is the company’s tight-lipped ([but loosening](#)) innovation lab that both oversees and emerged out of the self-driving-car project. It is known for impossibly lofty goals with a sci-fi twist; its director, Astro Teller, is officially titled Captain of Moonshots. Urmson shares a resistance to incremental advance.

“You make so much more progress when you’re thinking about changing the world rather than making this minor delta improvement on something,” he says. “You can get fired up in the morning.”

Urmson came into driverless cars like so many in the field: via three autonomous-vehicle challenges held by DARPA in the mid-2000s. The first Grand Challenge, in 2004, was a legendary disaster. Urmson was part of a team from the robotics institute at Carnegie Mellon led by the former marine [William “Red” Whittaker](#). The Carnegie Mellon car made the contest’s best showing despite traveling just 7 of 150 miles before getting stuck in an embankment. “Almost literally burst into flames,” says Urmson. At the next




A map of the Google car’s route through Mountain View during the author’s ride along. GOOGLE

Grand Challenge, in 2005, they placed second and third, losing to a [Stanford group](#) led by Sebastian Thrun, who later started Google's self-driving program. Urmson's team did win the 2007 race—an "Urban Challenge," notably, through 60 miles of a city environment.

He came to Google in 2009 to develop the self-driving car because it felt like something "that might change the world." Urmson knows the statistics on metro-area congestion. Americans spend 52 minutes a day commuting, he says, which works out to 4 percent of their lives. ("If I could give you 4 percent more life, you'd take it.") His bigger goal is safety, and he recites these numbers, too: 33,000 people a year die on U.S. roads; car crashes are the leading cause of death for people age 4 to 34; at least 90 percent of collisions are the result of human error. "So this is kind of a big deal," he says.

After accomplishing two baseline goals in its first 18 months—one, to drive 100,000 miles on public roads; the other, to complete 10 100-mile courses on challenging routes throughout California—the Google car spent the next couple of years conquering freeways. That seemed a "simpler problem" to tackle first, compared with city streets, says Urmson. Yes, higher speeds make the potential cost of any mistake that much bigger, but the fundamentals of freeway driving are pretty easy for programmers to model. Cars move in one direction, making minor adjustments to speed and position.

It's not just that surface street driving is far more complex than freeway driving, it's also unpredictably complex.



"To grossly simplify it," Andrew Chatham, the project's mapping leader, later tells me, "you follow the curve and don't hit the guy in front of you."

Cars move at slower speeds on city streets, but the number of variables is almost endless, and they require vigilant attention in every direction. There are tight lanes and traffic lights, pedestrians and cyclists, oncoming cars and double-parked trucks, unprotected turns and unexpected roadwork—the external elements are infinite, and configured differently each trip. So surface-street driving

isn't just far more complex than freeway driving, it's also unpredictably complex.

Take the problem of crosswalks at intersections. Sometimes pedestrians wait for the crossing signal and walk inside the lines. But sometimes they ignore the signal and cross as they please, and sometimes they're just waiting on the curb for a friend and don't mean to cross at all. Early on, the Google car had trouble categorizing these varying intentions and deciding how to respond. Now it's graduated to subtler problems, like spotting a pedestrian who might be standing behind a utility pole at the corner.

"It's the rarer and rarer situations we're working towards," says Urmson. "The complexity of the problem is substantially harder. But basically over the last year we've come to the conclusion it's doable, and that this intuition we had about making a vehicle that was fully self-driving was correct: that it was possible. That we actually think we can make one that really is safer than human driving."

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An interesting thing has happened in the car. We are in the left lane on Mountain View's West Middlefield Road when some roadwork appears up ahead. A dozen or so orange cones guide traffic to the right. The self-driving car slows down and announces the obstruction—"lane blocked"—but seems confused what to do next. It won't merge right, even though no cars are coming up behind us. After a few false starts, Brian Torcellini takes the wheel and steers around the cones before reengaging auto mode.

"It detected the cones and it tried to go around them, but it wasn't confident," says Dmitri Dolgov, typing at the laptop. "The car is capable of a lot of things, but unless it's absolutely sure that it can handle some situation well, it will err on the conservative side."

Boiled down, the Google car goes through six steps to make each decision on the road. The first is to locate itself—broadly in the world via GPS, and more precisely on the street via special maps embedded with detailed data on lane width, traffic-light formation, crosswalks, lane curvature, and so on.



A screenshot of what the Google car (in red) saw before getting stuck in a road work zone. GOOGLE

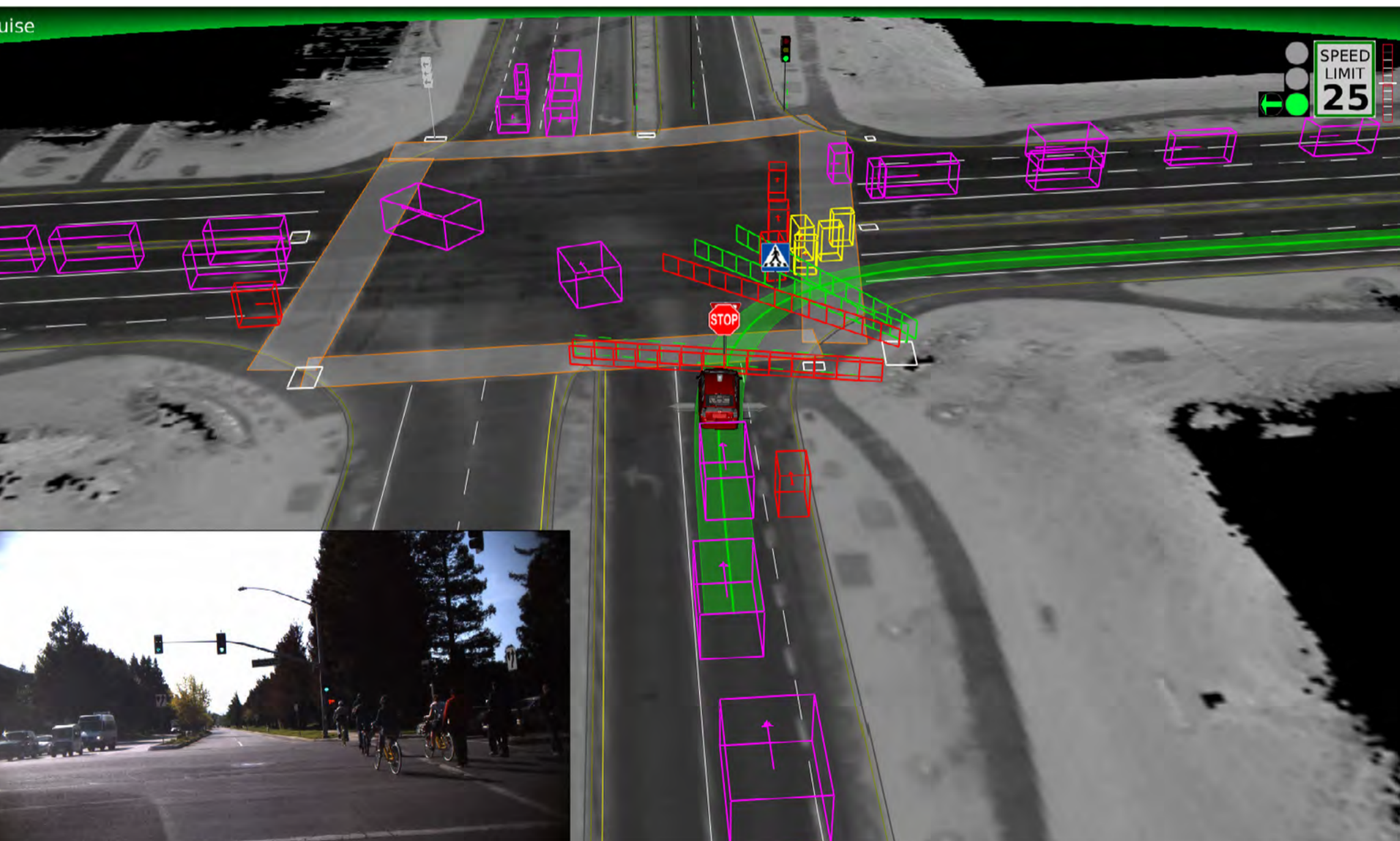
Urmson says the value of maps is one of the key insights that emerged from the DARPA challenges. They give the car a baseline expectation of its environment; they're the difference between the car opening its eyes in a completely new place and having some prior idea what's going on around it.

Next the car collects sensor data from its radar, lasers, and cameras. That helps track all the moving parts of a city no map can know about ahead of time. The third step is to classify this information as actual objects that might have an impact on the car's route—other cars, pedestrians, cyclists, etc.—and to estimate their size, speed, and trajectory. That information then enters a probabilistic prediction model that considers what these objects have been doing and estimates what they will do next. For step five, the car weighs those predictions against its own speed and trajectory and plans its next move.

That leads to the sixth and final step: turning the wheel this much (if at all), and braking or accelerating this much (if at all). It's the entirety of human progress distilled to two actions.

The map on Dolgov's laptop screen offers the best visual window into the car's mind's eye. Take the screenshot from one of our right turns (below). The baseline image is the detailed area map in grayscale. Layered atop that are objects identified by the car's sensors, depicted in colorful geometric boxes: purple for vehicles, red for cyclists, yellow for pedestrians. The red and green ladders are objects that have an immediate impact on the car's speed; in this case, though the traffic light is green, pedestrians prevent a turn, as does a cyclist coming up on the right—in a spot a human driver might easily miss. The flat green line shows the car's planned route.

Dolgov logs the roadwork incident in the computer. He explains that feedback from the driving teams is critical to the car's development. "Every disengage has a severity associated with it," he says. "That was not the end of



A screenshot of what the Google car sees approaching a right turn; inset, the view from inside the car. GOOGLE

the world. We would have gotten through the cones. But it was a problem. Once we go back, we'll pull the disk out of the car. We'll import the log from this run. This will get flagged to developers. It will go into our database of scenarios and test cases we track. We'll have more information about this on the desktops, but from what I saw on the screen, it looks like we detected [the cones] correctly, but for some reason the planner was conservative and decided not to change lanes. We'll create a scenario that says, here, the right thing would have been to change lanes, and the next versions will have it addressed."

A few minutes later, we turn left across five lanes of oncoming traffic onto California Street and reach our destination: an open-air market called the Milk Pail. Rather than stop, though, we head back toward the Google campus. At one point Dolgov and Torcellini realized air wasn't coming out of the A/C system because the vents weren't on. That was the biggest problem the car encountered until we'd just about reached campus. I had about closed out hope for more excitement when Dolgov makes an announcement.

"We wanted to make the ride a little more interesting for you," he says.

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Dmitri Dolgov is soft-spoken with (at least on the day we met) biblical patience for a reporter's repetitive questions. He arrived at Google in 2009, at the same time as Chris Urmson. They'd known each other from their DARPA challenge days, then as adversaries. Dolgov was part of Sebastian Thrun's group at Stanford. Evidently the rivalry still lingers; when I met everyone else later that day to discuss my ride, they brought it up unprompted.

"I was on a team that was not Chris's," says Dolgov.

"Came in second," says Urmson.

"Different years, different places."

"Same year, different places."

"Well," says Dolgov, "at least we didn't flip our car upside-down."

Race history aside, they share a clear belief that the self-driving car will have a transformative impact on road safety. Dolgov has been quoted as saying that if the car has to fail, he hopes it will “fail gracefully.” When I ask him to elaborate, he brings up the incident with the roadwork cones.

“It didn’t handle it as well as you would want to,” he says. “But it kind of failed gracefully. It saw the cones early; it slowed down smoothly.” One could imagine a less graceful car, say, plowing right through them. “The car needs to recognize its limitations and do the conservative thing given its limitations,” he says. “Even when that means being slower or being stuck.”

The Google car is programmed to be the prototype defensive driver on city streets. It won’t go above the speed limit and avoids driving in a blind spot if possible. It gives a wide berth to trucks and construction zones by shifting in its lane, a process called “nudging.” It’s extremely cautious crossing dou-



What the Google car sees as it approaches a railroad crossing. [GOOGLE](#)


ble yellow lines and won't cross railroad tracks until the car ahead clears them. It hesitates for a moment after a light turns green, because studies have shown that red-light runners tend to strike just after the signal changes. It turns very slowly in general, accounting for everything in the area, and won't turn right on red at all—at least for now. Many of the car's capabilities remain locked in test mode before they're brought out live.

"We have lots of things we turn off until we're confident," says Dolgov. "And if you had a self-driving car that handled everything else well but didn't do right on red? That's still a useful thing."

Google's self-driving "drivers" are programmed for caution, too. Torcellini, who's been behind the wheel since 2009, may have logged more driverless miles than anyone else on the planet. He has a breezy manner—in the Google-car movie he'll be played by Paul Rudd—but the driver-training program he's designing is a rigorous one. He recruits detail-oriented and disciplined individuals, several with military backgrounds. ("You can't have a Craigslist ad for people with that type of experience," he says.) He screens them with a driving interview. Once hired, drivers go through at least a month of training in both classroom and car, and must pass regular performance tests to ensure a steady development.

"It seemed like I had the easiest job in the world, just sitting around in a Lexus, but in fact we're paying really close attention to what the system is doing," he says. "We know we have the reputation of not only Google but also the technology [on the line] every time we take a car out of the garage."

**We're hugging
the curve when
suddenly we jam
on the brakes—
a utility truck
has cut us off
on the left.**



This safety-first culture gets a big assist from Google's developers, who don't need the cars to leave the garage to put them through several types of off-road simulation. They can invent a world using their CarCraft system to test out any road scenario imaginable. They can tweak the code and model hundreds of thousands of miles to determine what effect a change would have over time. They can even

take an instance when the driver disengaged and see what would have happened if the car had been left alone.

Inside the car, I found out what that means in practical terms: Google drivers don't have to get into an accident to learn from one.

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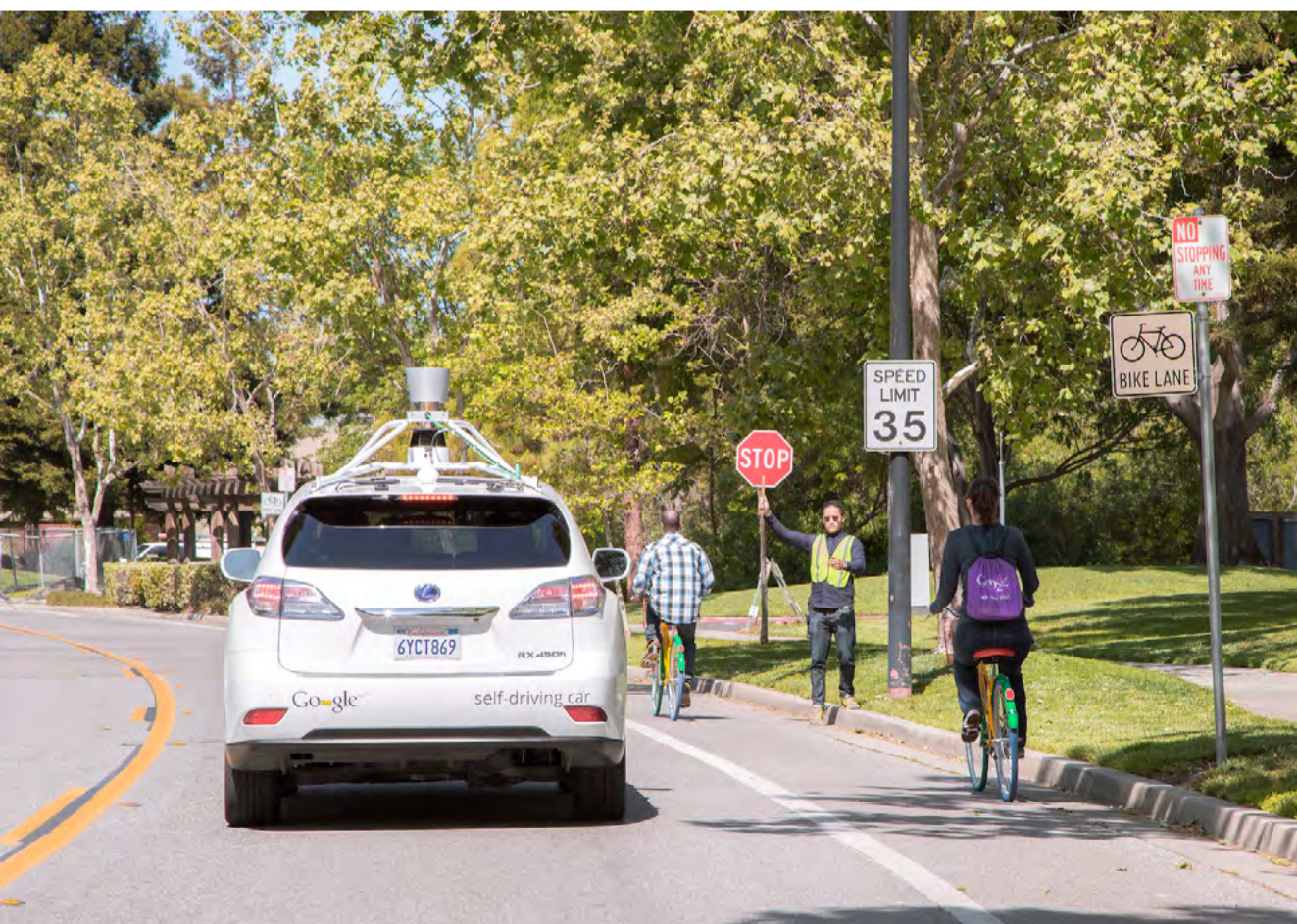
When Dolgov said they'd made the ride "a little more interesting" for me, he meant the team had staged a series of scenarios to demonstrate the full scope of the car's city-street capabilities. First we turned down a road and came upon a woman riding a red, green, and yellow Google bicycle in the shoulder. She held out her left arm, which the car's windshield camera detected and the software then identified as a turn signal. A little yield sign appeared above the cyclist on Dolgov's laptop, and the car slowed down until the cyclist cut left and out of harm's way.

The Google car can now recognize temporary stop signs, making it less reliant on pre-programmed maps. [GOOGLE](#)

The car then passed a few more staged tests. We slowed for a group of jaywalkers and a rogue car turning in front of us from out of nowhere. We stopped at a construction worker holding a temporary stop sign and

proceeded when he flipped it to slow—proof the car can read and respond to dynamic surroundings, making it less reliant on preprogrammed maps. We merged away from a lane blocked by cones not unlike the one that had stumped us earlier.

Urmson cites three big technological advances that have facilitated the car's shift to surface



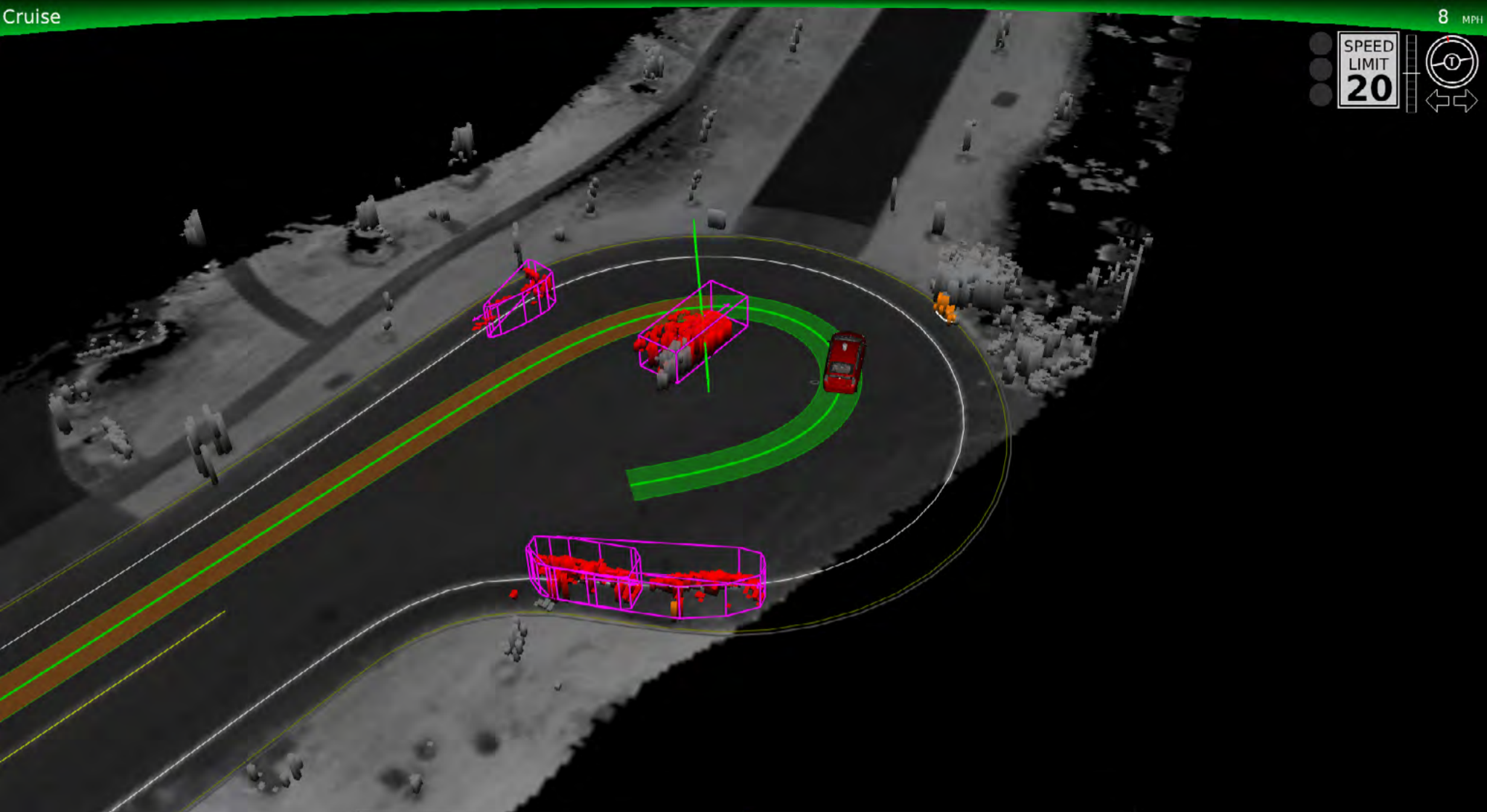
streets. The first is its ability to classify the objects around it. Early on, he says, they would be lucky to distinguish a car from a pedestrian; now they not only can tell the difference but can determine their travel paths. The second (and related) improvement has been in machine vision. That helps the car react to not only signals it expects, such as traffic lights, but those it doesn't, such as the stop/slow sign. The third step forward is in machine learning—the system's ability to interpret data and resolve a problem on its own.

One of the clearest examples of the car's progress is the way it turns left. Andrew Chatham, the mapping lead, explains that two years ago, the car made all left turns the same way: it drew a fixed path through the intersection and adjusted its speed accordingly. But over time the team realized that cars approaching a left turn at a green light follow a very different path than those starting from a stopped position. So now the computer recognizes this situation and computes a new route on the fly. It's those little tweaks that bridge the gap between a jerky, robotic ride and an amazingly smooth one.

Toward the end of my test run, after about a half hour of uneventful city driving, the car enters a cul-de-sac at the end of Charleston Street. We're hugging the curve when suddenly we jam on the brakes—a utility truck has cut us off on the left. A few moments later it becomes clear that Torcellini had disengaged auto mode and hit the brakes manually; the car probably had another second to decide on its own whether or not to stop, but rather than take the chance it wouldn't, Torcellini performed what he calls a "conservative takeover." I certainly hadn't seen the truck coming, and the palpable release of tension in the car suggested this wasn't one of the staged events.

"It's very easy for us to go back and simulate what the car would have done, had we not disengaged," says Dolgov, logging the incident. Later on I ask Torcellini what he thought would have happened if he hadn't taken over, and instead left the car to its own devices. "I think it would have stopped," he says. "It would have done the exact same thing I did."

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Top image: a screenshot of the Google car identifying the utility truck that cut it off.
Bottom image: Google's simulators determined that the car would have stopped before hitting the truck on its own. GOOGLE

Urmson met us after the ride to see how it went. I said I knew I wasn't supposed to compliment the car, but that the ride had felt amazingly smooth. He turned to Dolgov.

"Oh," he says, "you told him the first rule of self-driving."

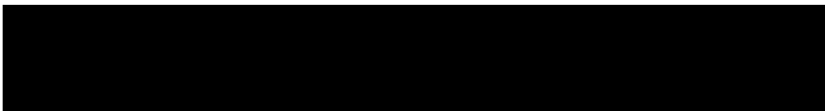
Urmson seemed a little disappointed that we'd needed to take manual control of the car twice. He says it took about six months of focusing on surface streets to get the basic foundation in place, but that accounting for all the nuances of city driving will take more time. "Driving where you did today, it's unusual that we would have disengaged twice," he says. "Compared to some of the situations you'll see on the road, a lot of what you saw today was pretty benign. It's stuff in your daily life; you might drive it without worrying about it too much. So now we've still got room to grow there, but we're pushing again on a few more of these longer problems. Trying to deal with smaller streets, less room to maneuver, more-difficult intersections—that kind of thing."

It's still too soon to declare victory in the race for driverless cars, but that hasn't stopped some experts from saying they expect autonomous vehicles on the road by 2030 (Nissan has pushed up its timeline [to 2020](#)). The history of self-driving technology is filled with premature confidence. At the 1939 World's Fair, the famed General Motors' Futurama exhibit predicted a world of radio-guided cars by 1960. In his recent *New Yorker* story on the Google car, Burkhard Bilger wrote that one of the team's lead engineers, Anthony Levandowski, keeps reminders "of all the failed schemes and fizzled technologies of the past."

Urmson knows all too well the hurdles that still remain. One of the main limiting factors is that any city where the self-driving car goes must first be mapped with a precision far greater than what even Google Maps achieves. That's doable in Urmson's mind: "We know how to deal with that scale of data," he says, referring to Maps and Street View. A greater challenge may be processing and codifying the myriad subtle social cues that remain so vital to navigating crowded city streets. Right now the car can't detect a driver trying to wave it into a lane, for instance, or someone requesting a merge through eye contact. And it still can't understand that universal language of urban traffic: honking. (It is, however, developing an "ear" for sirens.)

Then there is the matter of scale. Google has a goal of roaming all of Mountain View in the self-driving car by the end of this summer. That would be no small feat: the city has the feel of a typical college town, which makes it a great launching point for moving into many midsize U.S. cities, and its population of 74,000 no doubt rises considerably during the daytime hours, when the car roams its streets. But no one is mistaking it for San Francisco or New York or any other major metro area where traffic is so tightly packed and street behavior so wildly unpredictable that a super-defensive driver might suffer from paralysis by indecision.

“There’ll be lots of little wins between here and there, but that’s the big one.”




Still, Google is keenly aware what’s at stake. There’s the safety component, with cities recognizing the need to strive for [zero traffic fatalities](#). The nature of urban mobility itself is also on the line. Larry Burns, a former vice president for research and design at GM who’s now a paid Google consultant, says a taxi-like fleet of [shared autonomous vehicles](#) can become a viable business model if it can capture just 10 percent of all city trips. “I

think that should be viewed as a new form of public transportation,” he says. Having recently invested in the ride-sharing service Uber, Google no doubt senses that marrying urban travel demand with autonomous vehicles could [transform car ownership as we know it](#).

I asked Urmson when he’ll consider the car a success. “I think it’s a success when people are using it in their daily lives,” he says. “When we have cars out there and people are moving around and we have statistical data that says we’re saving more lives than had these people been driving themselves. The first time somebody who doesn’t work for Google is riding in one of these cars, getting to Grandma’s house or to work in the morning, or moving when they couldn’t otherwise move around the city, that’ll be a huge day for us. There’ll be lots of little wins between here and there, but that’s the big one.”

A few days later I got an e-mail from the Google press staff saying the self-driving-car team had run a computer model on the near-miss with the utility truck. Turns out the car would have stopped on its own with “room to

spare.” That sounds like one of those “little wins” Urmson mentioned, but I doubt he celebrated much. There’s a rule about that, and besides, the car already knew. 

PART 2

THE SMARTEST TRIP

The crucial connections between transportation progress and achieving sustainability.

How Denver Is Becoming the Most Advanced Transit City in the West

But the key question remains: will metro residents give up their cars?



Union Station is the centerpiece of Denver's FasTracks expansion program. TARAS GRESCOE

TARAS GRESCOE | *Originally published June 24, 2014*

DENVER—It's a vision straight out of a transportation planner's fondest dream.

In the center of the metropolis, the Beaux-Arts facade of a grand old railway terminus, finished in robin's egg-hued stone, is cradled by the daring swoop of a canopy of brilliant white Teflon. On one of eight tracks, a double-decked passenger train has stopped to refuel. A few hundred yards

away, German-built light-rail vehicles arrive from distant parts of the city, pulling into a downtown of soaring condo towers and multifamily apartment complexes. Beneath the feet of rushing commuters, express buses pull out of the bays of an underground concourse, and articulated buses shuttle straphangers through the central business district free of charge. A businessman, after swinging his briefcase into a basket, detaches the last remaining bicycle from a bike-share stand next to the light-rail stop, completing the final leg of his journey to work on two wheels.

An out-of-towner could be forgiven for thinking she'd arrived in Strasbourg, Copenhagen, or another global poster child for up-to-the-minute urbanism. The patch of sky framed in the white oval of the Union Station platform canopy, however, is purest prairie blue. This is Denver, a city that, until recently, most people would have pegged as an all-too-typical casualty of frontier-town, car-centric thinking.

"Denver is a car town," says Phil Washington, who has been general manager of the Regional Transportation District, metro Denver's rail provider, since 2009. Originally from Chicago, Washington joined the transit authority after a 24-year career in the military. "You've got to remember, not so long ago, this was the Wild West. Historically, everybody had their own frickin' horse. They'd strap them up on a pole outside the saloon. Folks feel the same way about their cars." (Washington notes that even the RTD headquarters—conjoined brick buildings in what is now rapidly gentrifying lower downtown—was once a notorious brothel, located a convenient stroll from Union Station.)

But in a state that recently voted to legalize the retail sale of marijuana, change is clearly in the wind. Ten years ago, Denver's new mayor (and current Colorado governor) John Hickenlooper began to ramp up a campaign to convince voters to approve an ambitious expansion of the region's embryonic light-rail network. A similar plan—fuzzy on such key details as routes and cost—had been defeated in a [1997 referendum](#). In 2004, the region's voters approved \$4.7 billion of new debt for the [FasTracks program](#). The plan, to add 121 miles of new commuter- and light-rail tracks to the region, 18 miles of bus rapid transit lanes, 57 new rapid-transit stations, and 21,000 park-and-ride spots, was approved [58–42](#), precisely reversing the results of the '97 referendum. (The price tag has since risen to \$7.8 billion.)

This is progress.
This is FaTracks.



RTD FaTracks
rtd-denver.com



A rendering of the Westminster Station on the Northwest Rail Line. COURTESY RTD

Washington attributes the approval of FasTracks, in part, to growing frustration with traffic congestion. An earlier program called T-REX (for Transportation Expansion) not only built a light-rail line to the city's southeast, but also widened Interstate 25, the region's main north-south axis. Following the apparently immutable [laws of induced demand](#), increased road supply led to increased traffic. Within a year, I-25 was just as congested as it had ever been. Voters, Phil Washington believes, came to the conclusion that transit offered a better path.

Another key factor in the referendum's success, Washington insists, was a concerted public-relations campaign. RTD, supported by the Denver Chamber of Commerce and the Denver Regional Congress of Governments (DRCOG), launched a communications blitz that had them doing presentations in schools and city halls across most of the region's 60 municipalities.

"From the start, we made it clear we weren't competing with the car," says Washington. "And we explained, to the average Joe, that for only four cents on most \$10 purchases, he'd be getting a whole lot of new transportation."

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Washington traces the progress of FasTracks on a poster-size map clipped to a whiteboard. Light-rail trains, on a track that branches south of downtown, already offer service to Littleton and Lincoln; extensions will see miles of new tracks penetrating even deeper into the southern exurbs. Last year saw the opening of the first FasTracks project, the West Rail Line, running through some of Denver's lowest-income neighborhoods to its terminus at the headquarters of Jefferson County. By 2016, the Gold Line to Arvada will offer further service to the west, and the East Rail Line will carry passengers to the airport; both lines will run heavy-duty commuter trains powered by overhead catenary wires. A rail line along Interstate 225 will create a loop east of downtown that Washington hopes will one day become a true circle line.

Only the Northwest Rail Line, says Washington, remains a question mark. Intended to bring commuters from downtown to Boulder and Longmont, along 41 miles of track, it follows a Burlington Northern Santa Fe Railroad freight corridor.

By 2016, a bus rapid transit system will offer service to Boulder, home to a university and cluster of tech companies that make it a major employment hub. The BRT [along U.S. 36](#) will be more than just a stopgap; plans call for it to continue to run in tandem with commuter rail. Washington concedes that the line will be something less than full BRT. The buses currently on order have only one door, significantly slowing boarding and unloading, and will run in regular highway lanes, rather than [dedicated busways](#).

By 2018, when all but one of the 10 FasTracks lines should be completed, a metropolitan area with a projected population of 3 million, spread out over 2,340 square miles, will be served by nine rail lines, 18 miles of bus rapid transit, and 95 stations. Many argue the project will turn Denver into the west's most advanced transit city, vaulting it beyond such better-known peers as Portland, Los Angeles, and Vancouver, British Columbia.

"We're witnessing the transformation of a North American city through transportation-infrastructure investment," says Washington. He foresees a not-too-distant future when Denverites will be able to access not only com-

muter and light-rail but also RTD buses, B-Cycle bicycles, and car-share vehicles using a single stored-value fare card.


“You’ll wheel your suitcase out of Denver International Airport, ride the train to Union Station, and hop a Car2Go—or even a B-Cycle if you’re traveling light—to your house or hotel. All using one card.”

It’s a beautiful vision, if one undermined by an uncomfortable truth. Denver’s mode share for transit—the proportion of people who use buses or

light-rail to commute—is only [about 6 percent](#). Contrast this with the Canadian city of Calgary, where a similarly sized bus and light-rail fleet operating in a similarly dispersed landscape draws in a mode share of nearly 17 percent. Even epically sprawled Atlanta and automobile-mad Los Angeles manage to achieve almost twice Denver’s per capita transit ridership.

In spite of all the inducements, Denverites, like eight in 10 Americans, continue to get to school or work the same old way: driving alone.

It’s a multibillion-dollar gamble on the future of transportation and the future of the American metropolis.



Will FasTracks make an appreciable number of people in Denver give up their horses—or their contemporary equivalent, private automobiles? The RTD is betting heavily that the answer will be yes. To achieve the transition, the agency is planning on changing not only the commuting habits of Denverites, but also the DNA of Denver itself, making it into a [far denser city](#).

It’s a multibillion-dollar gamble not only on the future of transportation, but also on the future of the American metropolis—one whose outcome other cities will be watching very closely.

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A trip to Denver, “The Queen City of the Plains,” once meant arriving in one of the continent’s great railroad towns. In its heyday, 80 trains a day passed

through Union Station—trains like the [Pioneer Zephyr](#), a kinetic sculpture of wraparound windows and streamlined stainless steel, whose record-breaking 13-hour run to Chicago, in which it topped out at 112 miles an hour, earned it the nickname “Silver Streak.”

Union Station, with its eight-foot-tall chandeliers and plaster arches lined with carved columbine flowers, announced Denver as an oasis of urbanity in the American West. Emerging from the Wynkoop Street entrance, travelers were met by the [six-story-high Welcome Arch](#), illuminated with 2,194 incandescent light bulbs. Incongruously, the arch was emblazoned with the Hebrew word *mizpah*, meaning “God watch over you while we are apart.” (Denverites liked to kid newcomers that it was the Native American word for “howdy, partner.”)



The grand opening of Union Station took place May 9, 2014. COURTESY RTD

The fate of Union Station mirrors the fate of rail in much of North America. The Welcome Arch, which came to be seen as a traffic hazard, was torn down in 1931. Private interurban lines that linked downtown to Boulder in the north and Golden in the west disappeared with the coming of freeways. In 1958, a bright-red sign entreating Denverites to “Travel by Train” was erected on the facade of the station. Air travel had begun to outpace rail, and Stapleton Airport had become the new gateway to the city. The streets around Union Station became Denver’s skid row, the stomping ground for [Jack Kerouac and Neal Cassady](#), whose epic cross-country road trips were usually made by car, not train. By the 1970s, many of downtown’s most elegant buildings, which went up at the height of the [City Beautiful movement](#), had been replaced by oceans of surface parking.

Change came with the new century. In 2001, RTD partnered with DRCOG to purchase the station and the surrounding acreage for \$49 million. Union Station, currently a construction site, will once again become the centerpiece of a renewed lower downtown, now rebranded “LoDo.” The station will continue to welcome Amtrak trains bound for Chicago and San Francisco, but will also be home to the Crawford Hotel, a 112-room luxury property, [set to opened in July 2014](#), with Pullman-style rooms and suites starting at \$252. Cranes currently pivot over residential condo towers, the tallest of them 21 stories. On the north side of the station, adjacent to the light-rail stop, a whole new residential neighborhood, Confluence Park, has sprouted up on what used to be weed-ridden, trash-strewn rail yards. An elementary school has opened its doors in a high-rise tower, and the local supermarket chain, King Soopers, has staked a LoDo branch (there are rumors a Whole Foods will follow). All told, the station redevelopment has spurred [\\$1.8 billion](#) in private investment.

“RTD is one of the largest property owners in Colorado,” says Bill Sirois, the authority’s manager of transit-oriented development. He describes dozens of developments going up around FasTracks stations. On the East Rail Line, the Urban Land Conservancy, a nonprofit that purchases land to serve community interests, has bought nine acres of land around the 40th and Colorado station, where it’s building 156 units of affordable housing. An eight-story housing complex for seniors is going up next to the 10th and Osage station. On the Central Rail Line, 275 new apartments are going up on a transit plaza adjacent to Alameda Station. All of these new developments

will be within a half mile of a FasTracks line and well within walking distance of a station.

The biggest success story remains downtown, whose residential population has [reached 17,500](#), a 142 percent increase since 2000. All told, FasTracks investment has brought 7 million square feet of new office space, 5.5 million square feet of new retail, and 27,000 new residential units. Driving demand for transit-oriented development, says Sirois, is Denver's changing demographics.

"We have a huge population of empty nesters," he says. "More and more, they're ditching their suburban homes and moving downtown."

Since the Great Recession, Denver has also become a [hotspot for Millennials](#), knocking out such car-centric rivals as Phoenix and Atlanta. Members of Generation Y are less likely to own cars (or to want to own them) and more likely to opt for transit or active transportation (such as walking or biking). They are also multimodal by instinct: a recent survey found that [70 percent](#) of those in the 25-to-34 age range reported using multiple forms of transportation to complete trips, several times a week.

All of this bodes well for the future of FasTracks. RTD is counting on not only increased residential density around stations, but also [the network effect](#)—the synergy that happens when new transit opens, making more parts of a region accessible to more users—to drive ridership forward.

"The system is developing and merging," says University of Denver transportation scholar Andrew Goetz. "The opening of Union Station is a major threshold. It's the intermodal heart of the network, bringing together rail and the regional bus system. The connectivity we're going to see as a result is going to be quite impressive."

There's evidence that Denver's transit mode share is already improving. Daily light-rail boardings [increased 15 percent](#) between 2012 and 2013. Even skeptics are starting to see a future for transit in Denver.

**"Before it was
a car town,
Denver was a
train town."**



“I remember, seven years ago, I’d be driving down I-25, and it would be completely gridlocked,” says Max Morrow, the owner of Max Lunch, a lunch counter next to Union Station. “A nightmare. In every car there’s one person. And I’d look over at the light-rail line that had just opened, and there’d be literally two people on every train. Now the trains are starting to get full. People in Denver love their cars, but they’re beginning to figure out the train system, and they’re using it.” Morrow, who is in his 40s, says he needs a car to carry supplies for work, but believes he’ll be leaning heavily on FasTracks. “I’ll be taking it downtown for ball games. You can sober up on the way home. As soon as the airport line’s open, that’s the only thing I’ll use. I’ll never drive out there again.”

Morrow’s employee, Zed Ireland, who is in his late 20s, already relies on light-rail. “There’s a bus stop behind my house. I take the bus to light-rail. It takes about half an hour to get to work. Two forms of transit, it’s not bad at all.

“When our baby is born”—Ireland and his wife are expecting their first—“we’ll probably get a car. But it’ll be mostly for my wife. I’ll still take public transit. And if we move, it’s going to be close to a light-rail line.”

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There’s a surprising amount of buy-in on FasTracks, even from traditional opponents of rail on either side of the political spectrum. Libertarians, who in many cities oppose rail projects as big-government “boondoggles,” have been remarkably silent in Denver. (This may be because the president of the local free-market think tank, the Independence Institute, is a former chair of the RTD board.) In Los Angeles and other cities, opposition to rail has also come from groups on the left, who label it Cadillac transit for the middle class, and argue lower-income workers could be better served by improved bus service.

“I think FasTracks is a great system,” says Melinda Pollack, a founding member of [Mile High Connects](#), a group that brings together nonprofits and foundations to advocate for affordable development close to transit. “When all the lines open, it’s really going to change connectivity for people. We’re trying to make sure that low-income people don’t get pushed away from the stations.” The group’s goal is to have 2,000 units of affordable housing opened near stations in the next decade.



Construction at the 38th and Blake Station, which is targeted for transit development in the future. COURTESY RTD

Such bipartisan support gets to a deeper truth about Denver: the region's deeply collaborative political culture has made it one of the [highest-functioning metropolitan areas](#) in the nation. In the wake of suburban tax revolts in the 1960s, the central city and neighboring communities chose to cast aside rivalries, cooperating to build stadiums and a new airport that would benefit the entire region.

The RTD has also reaped the rewards of regionalism. Rather than being forced to work with a variety of smaller agencies, RTD (like Vancouver's TransLink and Portland's TriMet) has authority over a large service area, allowing it to streamline the riding experience for users.

Denver's reboot as a train town isn't based on wishful thinking, or blind nostalgia for Gilded Age "choo-choo" trains. The engineers of FasTracks are well aware that Denver International Airport will continue to be the true gateway to the region. But as Kevin Flynn, an RTD public-communications manager who drives me out the airport-terminal worksite points out, once

off the plane, travelers will be able to ride escalators down to a platform to trains that will offer access to the entire region.

“I think our riders will be pleasantly surprised by our commuter rail,” says Flynn “They’ll be able to roll right onto our commuter rail from the terminal, with bicycles, ski bags, golf bags, wheelchairs, strollers, or whatever they’re carrying.”

Manufactured by Hyundai Rotem, the [new low-floor trains](#) (the next generation of the Silverliners already operating in Philadelphia) will reach maximum speeds of 79 miles an hour. Swiftiness, arguably, will be a less salient feature than frequency. Unlike traditional commuter rail, which too often offers only once-hourly (or worse) service outside peak periods, FasTracks trains will run with headways of as little as 10 minutes. They will also offer superior connectivity. As Flynn points out, military personnel and veterans from a seven-state area will be able to fly into Denver and

Construction on the I-225 Rail Line, with expected completion in 2016, from May 2014. COURTESY RTD



ride trains to the Veterans Affairs hospital at the Anschutz Medical Campus, a hub that already employs 40,000 people.

Back at the agency's headquarters, in LoDo, Phil Washington explains that RTD is building transit for a metropolis that, though born around rail, largely grew up around the needs of the automobile.


"There are at least five major employment centers in the Denver region," he says. Apart from downtown, the Anschutz medical center, and the airport, Boulder and the Denver Tech Center, on the Southeast Rail Line, are significant magnets for commuters. "The reverse commute we're seeing to these centers is incredible. Tons of folks."

It's a reality echoed in many decentralized cities, especially in the west and south: Only one in five jobs in Denver is located within three miles of downtown. For the time being, commuter and light-rail may deliver people to what looks like a low-density landscape of office parks and park-and-ride lots. (Which doesn't preclude future technologies, like autonomous buses and cars, delivering people from rail stations to low-density workplaces and suburban and exurban homes.)

By building a multi-poled system, RTD is tailoring transit to the contemporary metropolis. Crucially, by building it in conjunction with high-density transit-oriented development, the agency is also scheming to change the very nature of the American metropolis.

That's why, when it comes to the future of transportation on this continent, Denver may be the city to watch.

Surveying the airport construction site, where a hard-hatted Mayor Michael Hancock was presiding over the topping-out ceremony for the Westin Hotel, I played devil's advocate and asked Kevin Flynn if spending billions on transit in what has long been a car town was really worth it.

"Before it was a car town, Denver was a train town," he told me, with a smile. "For the time being, our infrastructure hasn't caught up with our ambition. Come back in a few years, and it'll be a completely different story." 



NATE BERG

What Running Out of Power in a Tesla on the Side of a Highway Taught Me About the Road Trip of Tomorrow

A lesson in range anxiety on the country's emerging Supercharger network.

NATE BERG | *Originally published April 29, 2014*

It's 209 miles from the parking lot of a Chili's in Barstow, California, where we are, to the parking lot of a Carl's Jr. in Kingman, Arizona, where we need to go. I'm in a rented [Tesla Model S](#), a sleek, battery-powered electric vehicle, with a travel companion. We're just about fully charged, and the car estimates it can travel 247 miles before we need more juice. That's a buffer of 38 miles, which should be more than enough to reach Kingman. We'll soon realize it isn't.

The seemingly random parking lots I'm traveling between are sites of a new nationwide network of fast battery-charging stations for drivers of Tesla's Model S. The company calls them "[Superchargers](#)"—direct-current battery-charging stations of a proprietary design that can bring a nearly dead Model S battery to full charge in a little over an hour. That's much faster than the roughly 8 hours it would take by plugging into a wall outlet in your ga-

rage. Tesla's official reason for building this private network of battery-charging infrastructure (currently up to 80 stations and counting) is to encourage Model S drivers to take road trips—a concept otherwise unthinkable in a car powered only by a battery. I'm testing it out on a weekend road trip from Los Angeles into Arizona and back.

For drivers of electric vehicles, calculations of distance and range are a near-constant concern. How far you want to go must always be less far than your battery can take you. The Nissan Leaf, for example, can get up to 84 miles of range on a full charge—enough for most people's daily commutes and errands, but hardly a long-distance option. The estimated 265-mile range of a fully equipped Tesla Model S has allayed some concerns about having enough juice to get where you want to go. Coupled with the Supercharger network, it's made the idea of taking a battery-powered road trip feasible—even cross-country. Feasible, I quickly find, is not the same thing as simple.

A Tesla Supercharging station in the parking lot of a Chili's in Barstow, California. NATE BERG



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An hour outside of Barstow I notice on the digital dashboard display that our 38-mile buffer has fallen hard, to about 20. We panic. We've got more than 100 miles to go, a lot of it uphill, and if the buffer keeps decaying at this rate, we'll never make it. I'd been driving as I normally would, not realizing that higher speeds and the rising elevation would drain the battery faster—that “estimated” range really is just an estimate. In any effort to save battery life, we turn off the stereo and dim the huge touch-screen control panel. I figure out the cruise control and drop it down to 63. We coast and hope.

We're mostly in the slow lane now, venturing left periodically to pass a big rig. But we're not going much faster than the trucks are, and passing takes longer than usual. One truck driver doesn't take kindly to this gradual pass and offers us his middle finger. Our passing speed is apparently too slow for his liking, and he edges his truck into our lane. Properly intimidated and terrified, I slam on the accelerator, temporarily abandoning the cruise control and draining that much more of the battery's life. Once he's far enough behind, I slow back to 63, but it takes a long time on these straight desert roads for his headlights to finally disappear from the rear view.

About 15 miles from Kingman, the estimated range finally drops below the distance remaining to travel. The battery's display bar has shrunk and dimmed from bright green to grayish day-old avocado. The range keeps ticking down. We're about 7 miles away from the Kingman Supercharger when the battery range officially reads zero. Basically on empty, we keep going for a few more miles before the car begins slowing itself down. The car is shutting off, the display says, and I pull onto the shoulder, park, and call AAA.

We're 3 miles from the next Supercharger station with a dead electric car on the side of a barren desert highway. It's 12:30 in the morning. That psychotic trucker can't be too far behind.

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The all-electric-vehicle market is in its infancy. Tesla estimates that there are [about 25,000 Model S](#) cars on the road worldwide, 22,450 of which were

sold in 2013. That's about 0.03 percent of all the [82.8 million vehicles](#) sold last year. It's still a small minority.

As things stand, the market has three main constraints: the limits of battery capacity, the time it takes to charge them, and the availability of charging stations. The limited range of electric cars has created a reliance on easily accessible charging, most of which takes place either at home or at work over the course of hours. But if people want to use their cars to get more places than just work, home, and the errands in between, they'll need more and faster public charging stations. A fair amount exist in many urban areas, and [various online maps](#) plot out where drivers can add a little juice to their batteries while out in the world. But for the market to grow, this infrastructure really needs to be almost ubiquitous, says Michael Nicholas of the University of California at Davis Plug-In Hybrid and Electric Vehicle Research Center.

"If you ask a customer, most people would say they want it everywhere. But then there's obviously not unlimited resources for host sites to install chargers," he says. "That's the thing: in the start of the market, you need more chargers per vehicle to enable the range of driving possibilities."

The availability of charging stations will likely become less important over time, as battery technology improves and range increases. Tesla's 265-mile-range lithium-ion battery packs are leading the field, and the company is hoping to extend that dominance with a recently announced plan to invest about \$5 billion between now and 2020 on a [new battery factory](#). But for now, those longer-life batteries are expensive, and most electric or hybrid electric vehicles are limited to much more modest ranges.

"Range will be an issue for a very long time, unless a miracle battery shows up that is safe and cost-effective," says Britta Gross, who heads the electric-vehicle-infrastructure program at General Motors. She says cost is why the battery in GM's \$35,000 Chevrolet Volt has only a 38-mile range. Additional range would make the car more expensive than GM prefers.

That means driving in an all-electric vehicle like the 84-mile-range Nissan Leaf is, for now, confined to daily commutes and errands. For longer trips, the accessibility of charging stations—and especially the amount of time it

takes to charge—are major limiting factors. When it comes to the electric vehicle road trip, a Tesla is basically the only option.

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It's nearly 2 a.m. by the time a tow truck arrives. A half hour later the driver tells us he can't tow us and, frankly, he's a little afraid of messing anything up on a car that's worth nearly \$100,000. When the shop opens the next morning, he assures us, somebody should be able to come right out. With few other reasonable options, we accept a ride in the tow truck to a hotel in Kingman, 3 miles away—leaving our \$100,000 rented commodity in the darkness on the side of the interstate.

Four hours later we're awake again, on the phone to AAA. They can't find anyone who's willing to take on the liability of towing a fancy car. After hours of calls back and forth, they say they've finally found a truck willing



NATE BERG

to jump and tow us. We convince a local cabbie to drop us off on the side of the interstate where we left the car eight hours earlier, but our hero truck never comes. I call AAA after an hour, and they promptly hang us out to dry, saying, essentially, “Sorry, we aren’t willing to take on the liability of helping you.” We have entered an episode of *The Twilight Zone* written by Franz Kafka.

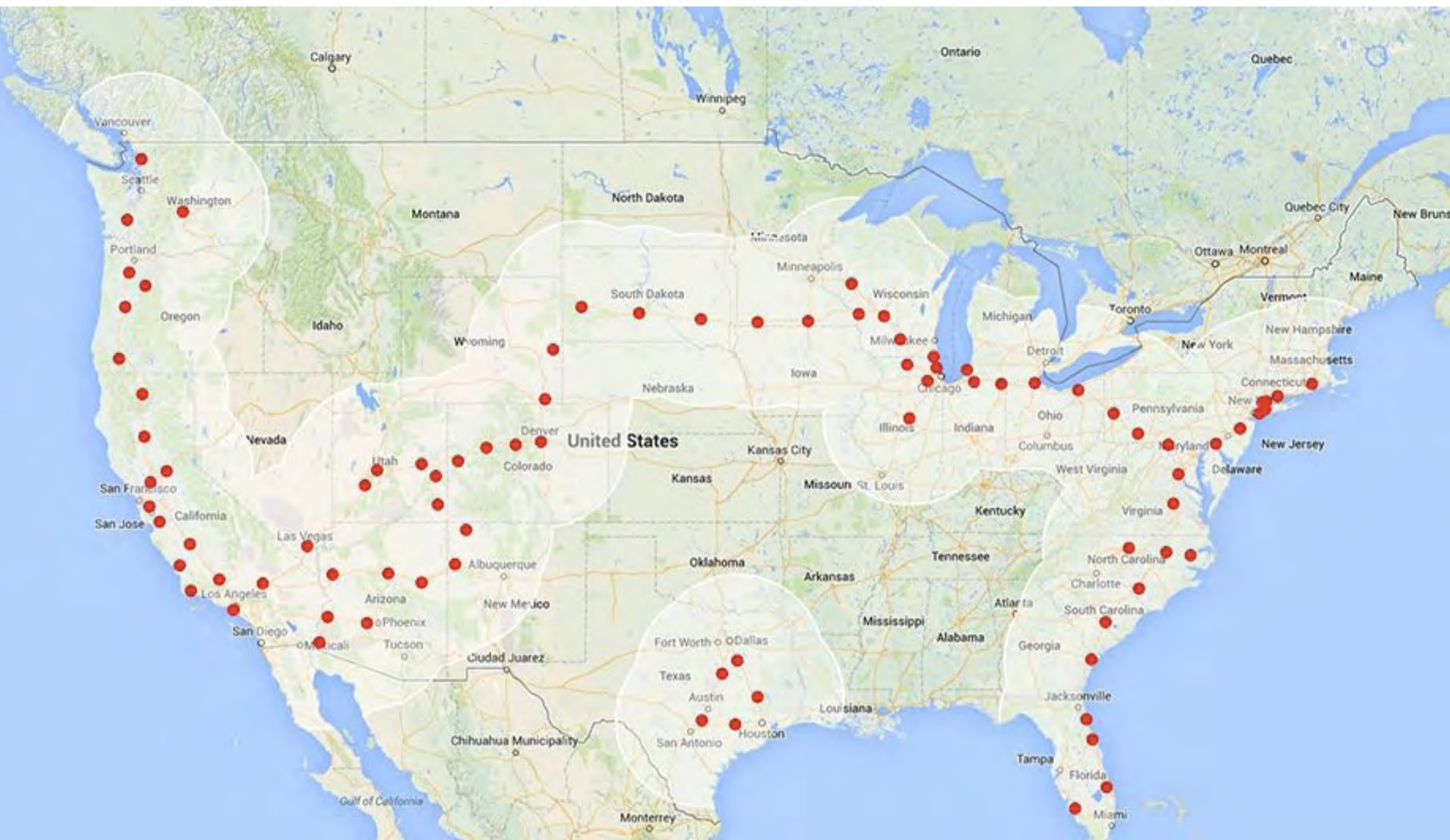
In the meantime, we’d also been calling the roadside services of Hertz, from whom I’d rented the car, as well as Tesla. They’d also been trying to convince a local tow company to come get us, with no luck. We’d been blacklisted by the tow companies of Kingman—“Oh, you’re the Tesla,” they’d say when I called. “Sorry.” Though any idiot can rent a fancy electric car, I’m apparently the only one who’s broken down near Kingman, Arizona.

Eventually Hertz and Tesla manage to get somebody out to save us. The tow truck driver, assisted by Tesla’s roadside-service guy on the line, figures out how to jump the car and give it enough juice to turn on and robo-shift into neutral. Fifteen minutes later, it’s on the back of the truck on its way to the parking lot of the Carl’s Jr. Tesla generously picks up the \$165 tow charge, and by the time our driver drops us at the Supercharger station, his company has become the go-to tow service for any other Tesla in need of roadside assistance in the Kingman area.

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A map on Tesla’s website shows the locations of the 80 Supercharger stations now in operation, and the radius of range around each that drivers can theoretically reach. The dots of the stations cover the entire length of the West Coast, most of the East Coast, a squiggle from the Southwest through the Midwest to the Northeast, and a separate triangle in Texas. The combined radii of range covers a pretty good amount of the country, and the company has its sights on extending that coverage significantly. By the end of 2014, they expect to be able to reach 80 percent of the U.S. population. By the end of 2015, they hope to reach 98 percent.

But while the Superchargers will enable drivers to reach most of the country, the Superchargers themselves will be relatively few. According to Tesla,



Tesla's Supercharging network spans the United States (above, a map screenshot). [TESLA MOTORS](#)

there will be about 250 by the end of next year, located mostly along well-traveled interstate highways and typically in small towns.

“Supercharging is most beneficial between city centers, as opposed to within them, so by placing them along major corridors, we are enabling Model S owners to truly drive freely,” Tesla spokesperson Patrick Jones wrote in an e-mail. (The company declined to make any officials available for an interview.) In cities, people are able to plug in at home and work, and don’t really drive far enough to benefit from fast charging. The Superchargers are an every-once-in-a-while sort of amenity. “We believe that our Supercharger network is a game changer for the EV market and is the answer to lingering questions about long-distance travel or so-called ‘range anxiety.’”


And while enabling road trips is certainly a worthy cause for some drivers, observers of the electric-vehicle market see the Supercharger network mostly as a marketing tool. “They are selling the idea that you can travel across country in your electric car, but the number of people who do it is

probably not all that high,” says Nicholas, the UC Davis researcher. “It kind of takes away that mental barrier of ‘This electric car can’t do what my gas car can do,’ and sometimes people need that kind of assurance to buy the car in the first place.”

Tesla won’t offer any details about how much it costs to build and operate these Supercharger stations, but according to internal [documents obtained](#)

[by TechCrunch](#), they’re an expensive effort, marketing or no. Each Supercharger station is estimated to cost between \$100,000 and \$175,000, and Tesla is picking up the entire tab—from installation to maintenance to the cost of providing the large amount of energy needed to charge the cars so quickly. Nicholas says Tesla is internalizing this cost and adding it into the price of the Model S, which can range from about \$70,000 to more than \$100,000.

Each Supercharger station is estimated to cost between \$100,000–\$175,000, and Tesla is picking up the entire tab.



For the landowners of Supercharger sites, the cost is basically nothing, aside from agreeing to dedicate an average of four or five well-lit parking spaces to the chargers for a period of five to 10 years. Like the Superchargers I visited in Barstow and Kingman, most of the stations tend to be located near hotels, fast-food or casual-dining chain restaurants, and (perhaps somewhat incongruously) gas stations. But there’s a logic to that: Superchargers are essentially just plugs attached to utility boxes, and don’t have common roadside amenities like restrooms or snacks. Last June, Tesla [made a deal](#) with shopping-mall developer CBL & Associates Properties to site Superchargers at five shopping malls nationwide. Many others on the map are located near malls and retail outlets. An hour to kill while charging your car might just as easily be an hour to shop.

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When you park a Tesla in a Supercharger station, people take pictures. Random people walk by slowly. Enthusiastic car nerds come to get up close. Men, women, and children alike stare. The driver of one of the other two Teslas we saw at the Kingman Supercharger was even taking pictures of his

own car. He was [Instagramming](#) and [tweeting](#), it turned out, to document a road trip he was taking from L.A. to Virginia and back—a coast-to-coast-to-coast journey powered solely by Superchargers that he guessed was probably the first attempted.

“The reason I’m here doing this is to show that it’s possible right now to get anywhere you want to go on the Supercharger network,” says Sam Weinstein, who along with a driving partner, was at his third Supercharger stop of the day. He expected to be in Virginia to visit family within four days.

A Tesla Supercharging station at the Carl’s Jr. in Kingman, Arizona. NATE BERG



The engineers at Tesla probably couldn't have invented a better pitchman than Sam Weinstein. He's an unabashed Tesla fanatic. He put down a \$5,000 deposit just to get a chance to test-drive a Model S. Later, when he was waiting for the car to be delivered, he'd go to the Tesla store in Santa Monica and just sit in the display model. He ducks into the driver side of our Model S to show me how to find the car's specs on the display. He shows me an app on his iPhone that monitors the charging status of his own car, plugged in two stalls down. He e-mails me a screenshot.

I called him in mid-March, after he'd returned to Southern California, to hear how the rest of his trip went. Aside from a flat tire in South Dakota and a range-taxing diversion around a jackknifed big rig in Minnesota, the 7,500-mile round-trip was basically smooth. He sent me a spreadsheet of data from the car's return-trip, with mileage, average speeds, and the amount of battery range he had at the beginning and end of each leg between Superchargers. There were a few nail-biters, with just three or four miles of range left by the time he plugged in, but the trip was mostly a breeze.

"I knew in advance that I would have to be careful, that I would have to be judicious in certain spots where there was a longer gap," he says. The average distance between the 32 Superchargers he visited from Virginia to California was just 120 miles, which makes our breakdown on the 209-mile stretch between Barstow and Kingman even less surprising. These are the first days of the electric-vehicle road trip. There are certainly kinks in the limited infrastructure Tesla has so far built, but getting generations of people used to the convenience of combustion engines and gas stations to adjust their driving and mobility patterns may be a bigger hurdle. Weinstein sees these as necessary stumbles on the way to a better future.

"For me, I know that this is the least comfortable it will ever be for anyone," he says. "Since I got back here, they've already opened another Supercharger."

Weinstein's enthusiasm aside, the present Supercharger network offers only a few road-trip options from any given point. After Kingman we'd planned to go to Flagstaff, Arizona. That was before the 12-hour breakdown. By the time we finally recharge, it's raining there, with a chance of snow, so we head to the only other reasonable option: Las Vegas.

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For all the techno-boosterism surrounding the Supercharger network, there's also a fair amount of skepticism about just how important a nationwide system of road-trip charging stations can be to the electric-vehicle market. For one, the electric vehicle of the near future probably won't be just electric.



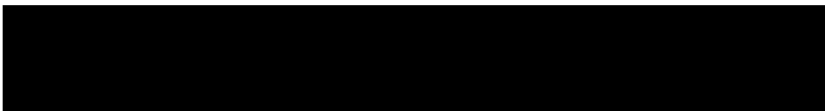
NATE BERG

“In the future, everything will be a form of what we now call a hybrid,” says Timothy Lipman, co-director of the Transportation Sustainability Research Center at UC Berkeley. He foresees a greater variety of hybridizations combining oil, natural gas, electric batteries, hydrogen fuel cells and maybe some as-yet-undeveloped alternative-fuel options. He agrees that battery technology will continue to improve and therefore increase the range that

cars will be able to travel using just electricity. But, when combined with other fueling technologies, there'll be something to supply more power when the battery runs out, potentially making public charging infrastructure largely irrelevant.

GM's Britta Gross agrees. "These sort of bi-fuel mixtures mean we don't have to wait for infrastructure. We don't have to wait for everyone to figure out how infrastructure happens," she says, noting its expense. "It should not be an issue. Public charging is not a necessity." She calls public charging infrastructure like Superchargers "nice for awareness."

"In the future, everything will be a form of what we now call a hybrid."




For the time being, all-electric vehicles like those made by Tesla are somewhat limited to a certain type of driver—one who only needs to go so far on a regular basis and for whom the occasional road trip can be constrained by the availability of charging infrastructure. Tesla plans to expand its Supercharger network and reduce those constraints, but the reality re-

mains that a Tesla is simply less versatile than a gas-powered car. This likely won't always be the case, and the Supercharger network is one major way of changing the paradigm now. Better batteries—also on Tesla's agenda—are the other, and they'll likely be the more important effort of the two.

Las Vegas has one of the few inner-city Superchargers in Tesla's emerging network. It's mostly there because of the Downtown Project—the urban-revitalization plan/tech incubator/real-estate plaything of Zappos CEO Tony Hsieh—and an affiliated car/bike/ride-sharing program called [Project 100](#). Its "invite-only beta operation" is supposed to begin sometime this year, and there will eventually be 100 Tesla Model S cars available either for sharing or for on-demand driving services on downtown streets. One can imagine, with that many Teslas on the road in one neighborhood, there will be some long lines for the six Supercharger stalls. For now, the demand is low enough that we were one of only three cars charging on a Sunday afternoon.

Once we had a comfortable 250 miles of range, we set off back for Barstow. We made it with plenty of range left, and topped off before heading back to

L.A., again with no problems. We'd learned our lesson about driving this particular car in this specific situation, and ended our electric-car road trip on a successful note. In fact, I was a little sad to have to return the car. It felt a little like coming back to the present after a brief visit to the near future. Back in the year 2014, I caught a cab home. But even that's changing. The cab was a Prius. 



A rendering of All Aboard Florida's rail station in downtown Miami. COURTESY ALL ABOARD FLORIDA

The Triumphant Return of Private U.S. Passenger Rail

Can new train service between Miami and Orlando be a model for the rest of the country?

HENRY GRABAR | *Originally published June 17, 2014*

MIAMI—Beginning in 2016, [All Aboard Florida](#) will run 32 departures a day between Miami, Fort Lauderdale, and West Palm Beach, with service extending to Orlando. With a maximum speed of 125 miles an hour, the trains will complete the 240-mile journey in less than three hours. In South Florida, around the three initial stations, the company will develop 4.2 million square feet of real estate. In Orlando, the terminus will be located at the

airport and connect to a new commuter-rail line at a sparkling, state-funded [\\$215 million transportation hub](#).

It's a big project by any standard, but it looms even larger in historical context. No private intercity passenger-rail line has operated in the United States in 30 years—and it has been longer still since a new service was introduced. “You’d have to go back over 100 years to find a significant investment in private intercity rail in the U.S.,” says David Levinson, a transportation analyst at the University of Minnesota.

Broadly speaking, there are two reasons All Aboard Florida [may be able to revive](#) a transportation model whose decline began during the Hoover administration. The first might be called *what is already there*: a coastline’s worth of right-of-way, half of Florida’s population, and tens of millions of travelers on business and vacation. The second might be called *what could be there*: 15 acres of transit-oriented development in three South Florida downtowns.

Can All Aboard Florida establish a blueprint for how private freight railways, which averted financial ruin by abandoning passenger service, can profit from its revival? “If it can work there, it could work in other markets. The other private rail firms absolutely can be watching this,” says Adie Tomer, an associate at the Brookings Institution’s Metropolitan Policy Program who studies passenger rail. “This a great test for America.”

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Private, intercity passenger rail in America has been dead since 1983, the year the Rio Grande Zephyr, which ran through the Rockies between Denver and Ogden, Utah, was folded into Amtrak’s California Zephyr route. That was the final bow of a long fifth act that began with the ascent of the American automobile six decades earlier. The number of passenger trains in the United States dropped [45 percent](#) between 1929 and 1945, and [85 percent](#) between 1929 and 1965.

Today, America’s passenger trains are operated publicly by Amtrak. Conceived as a political escape valve to relieve freight companies of the burden of passenger service, Amtrak was never expected to succeed, says Albert




A ground-level rendering of the Miami Station. COURTESY ALL ABOARD FLORIDA

Churella, a historian of the Pennsylvania Railroad. “It was made very clear to everybody—*wink wink, nudge nudge*—that in a few years we’re going to shut all this stuff down,” he says. Amtrak has survived thanks to its political appeal and popularity, but not because it’s good business; it receives more than \$1 billion in taxpayer subsidies each year.

All Aboard Florida, however, has a couple of inherent advantages. The first is in its infrastructure. As a corporate descendent of the Florida East Coast Railway, AAF owns an easement for passenger service on a long, centrally located, well-maintained freight corridor. The second is demographic. On the strength of Disney World, Universal Studios, and other theme parks, Orlando is the most visited city in the United States, with nearly [60 million tourists](#) last year. Miami, with its global cachet and thriving cruise-ship port, counted [14 million visitors](#) in 2013. All Aboard Florida says that 500 million trips are made every year between its destination cities.

So AAF will set a passenger railway in motion. With 32 trips each day and a train capacity of 400 travelers, the service can theoretically carry more daily riders between Miami and Orlando than Amtrak's Acela does between New York and Washington, D.C. Tourists and in-state leisure travelers will account for nearly three-quarters of AAF ridership, with business travelers making up the rest. (It's virtually the inverse of the Acela's business-heavy traveler ratio.)

“Our expectation is that the train will be profitable, in and of itself.”



“Our expectation is that the train will be profitable, in and of itself,” says John Guitar, senior vice president of business development at AAF.

It's a daunting goal. The Florida Fun Train, which ran between Fort Lauderdale and Tampa during the late 1990s, [vastly overestimated](#) tourist demand in the region and shuttered

after less than a year of operation. A [Congressional Research Service report](#) estimates that ridership levels needed to justify the cost of high-speed rail start at 6 million annual riders. The maximum number of Miami-Orlando tickets that AAF can sell each year will be 4.7 million.

There is [one place in America](#) where passenger rail operates in the black. Amtrak's Acela and Northeast Regional trains, which serve the dense Boston-Washington megalopolis and its population of 50 million, count 11.5 million annual riders between them. The Acela's operating surplus, the larger of the two, was \$237 million in Amtrak's 2013 fiscal year.

But Albert Churella is quick to clarify that those figures constitute the “above the rails” profit, and don't account for capital costs like buying trains, laying tracks, and keeping the whole system in good repair. “Doesn't the Northeast Corridor make a profit?” he says. “Only if you assume that the entire physical bed just dropped out of the sky for free.”

Mike Reininger, the president and chief development officer of All Aboard Florida, says building and owning infrastructure are not disadvantages in the long run. “There are a number of these privately operated and profitable businesses in this space,” he says, pointing to an [Italian high-speed](#)

[service, Italo](#), which debuted in 2012. “What’s interesting, however, is that while those businesses are profitable, they’re profitable even after they have to pay an access fee to utilize the infrastructure they rely on.” Instead of paying such a fee, AAF will pay construction costs: building tracks and stations, and upgrading signaling, bridges, and grade crossings.

The cost of the project, says AAF, will be in the neighborhood of \$2.5 billion, of which \$1.6 billion is expected to come from an RRIF loan from the Federal Railroad Administration. Will AAF transport enough people to pay off that loan? Two years ago, in documents submitted to the Florida DOT, AAF cited a preliminary ridership study that estimated it could ultimately book 3.9 million trips each year, with [annual fare revenue](#) of \$145 million. (Reininger says those figures are conservative, but declined to disclose current projections.)

Under that projection, and assuming a profit margin roughly equivalent to the Acela’s, AAF would pile up profits approximately equal to annual debt service on the loan. But the passenger-rail business seems unlikely to meet what Vincent Signorella, CEO of Florida East Coast Industries (AAF’s corporate parent), told *Florida Trends magazine* last year was the company’s benchmark for investments: doubling its money.

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Henry Flagler, founder of the Florida East Coast Railway, has been called the “man who built Miami.” There were hardly 1,000 people living on the edge of Biscayne Bay when Flagler’s tracks reached South Florida at the turn of the 20th century. But that, writes historian Les Standiford in *Last Train to Paradise*, was his method: “Build a railroad to a place, erect a destination-worthy resort hotel there, and other development was sure to follow.” There are streets named for Flagler in nearly every town on Florida’s Atlantic Coast—including the four served by AAF’s new route.

“When Henry Flagler did his rail line, real estate was a big component,” Jose Gonzalez, executive vice president at FECI, told attendees at a presentation in May. “And it still is today. He would be very proud of the way we’re looking at it.”



Henry Flagler, founder of the Florida East Coast Railway, has been called “the man who built Miami” (above, an undated postcard). WIKI COMMONS

Over the past few years, AAF has quietly assembled a total of 15 acres of land in the downtowns of West Palm Beach, Fort Lauderdale, and Miami. Most of that property is in Miami, where the company still owns the nine acres on which Flagler’s rail yards once stood. Today the site is an eight-block parking lot served by two stations of Miami’s Metrorail line and two stations of the [downtown people mover](#). To this site AAF has added an additional two acres, purchased from a Miami Community Redevelopment Agency in September 2013 for \$2.7 million.

Right now the area is desolate. “Everything on this site by 5 o’clock is dead. All the county workers leave, and there’s no life here,” says Gonzalez, who described the company’s plans as we drove through the neighborhood. The only residents in this part of downtown Miami are the homeless, encamped along the chain-link fence that marks the northern edge of Flager’s property.

When passengers begin arriving in downtown Miami on intercity trains, in 2016, All Aboard Florida plans to have transformed this neighborhood. There will be a colossal station complex designed by Skidmore, Owings and Merrill that includes a half-dozen towers, over 1 million square feet of office

space, 1,111 residential units, a hotel, car-rental outlets, parking, and blocks of ground-floor retail facing the street. (One tower, planned for 70 stories, will be among Florida's tallest.) The main station will arise at the northern edge of the property, across from Metrorail's Overtown stop, while the skyscraper anchors the southern edge. Shoppers, residents, workers, and travelers will be able to walk from one end of the development to the other along an internal concourse that bridges several downtown cross streets.

Gonzalez says real-estate prices have been rising around the site. "The station will not only bring the people, it will bring a mix of uses, and it will help be a catalyst for all these real-estate opportunities that have been, for the last decade, passed over. You're going to come back in 10 years and say: 'How did this not happen sooner?'"

It appears to be a classic study in [value capture](#), a catchall term for the variety of practices that governments and developers use to profit from rising land prices spurred by changes both physical, such as a new rail line, and legal, such as a new zoning code. In AAF's case, intercity rail is transforming a lifeless downtown into a hot commodity right as transit-oriented development is enhancing the appeal of carless travel. "What we are really doing is building a platform comprised of two businesses," says Reininger, referring to rail and real estate. "They hold hands, exist independent of one another, but each makes the other one better."

What's happening in downtown Miami is straight out of the Flagler playbook. People both inside and outside of All Aboard Florida talk about the station development as a catalyst for transit-oriented development downtown. On two empty acres to the west of the Miami station site, the developers Baron Channer and Don Peebles are building Overtown Gateway, which will include a 150,000-square-foot hotel, 400 apartments, and a mix of retail designed to create an entertainment district. Across the street from the station, to the east, a mammoth development called [Miami World Center](#)—with 1 million square feet of retail, a 600,000-square-foot convention center, and an 1,800-room Marriott—will break ground later this year.

And yet, the underlying consensus in Miami seems to be, as the Brickell City Center developer Stephen Owens puts it, that All Aboard Florida's development is more complement than catalyst. Downtown Miami is finally filling



Empty storefronts line North Miami Avenue, one block from All Aboard Florida's future station complex (top, rendering). COURTESY ALL ABOARD FLORIDA; HENRY GRABAR

up. The population has nearly doubled over the past decade and a half, from less than 40,000 at the turn of the millennium to more than 75,000 today. In a city where growth is driven by mega-projects, no urban fabric is no problem. This part of the city may look bleak to outsiders, but local developers view its growth as the inevitable next step in the revival of downtown Miami.

The question then becomes: Is the value in downtown Miami being created by transit, or is it merely the fruit of a half century of land banking? That might seem like water-cooler talk for Miami real-estate brokers, but the answer will go a long way in determining whether All Aboard Florida is the exception to private U.S. passenger rail or the new rule.

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Florida East Coast Industries has the opportunity to set an example for American freight railroads, says the Brookings scholar Tomer, a Florida native who has been watching the project closely. “For these rail firms—which often also hold parcels in places, more than you’d think—that’s an incredible opportunity to re-jump passenger service by being able to collect rents on their land ownership.”

Unlike the activity around commuter rail, subways, and other daily-use transit, the financial spillover effect of a high-speed-rail station is not clearly established. “The evidence that’s looked at the economic development effect of high-speed rail has shown that there’s not a whole lot of local effect,” says Levinson. “A comparison is to the airport: What frequent business traveler is going to live next to the airport?”


And yet, [research has shown](#) that when high-speed rail *does* produce big gains, it’s when the new station is part of a wider regeneration effort in a depressed, post-industrial center city. South Florida’s hollow downtowns seem to fit that profile.

More than the flagship development in the hot Miami market, All Aboard Florida’s investments in West Palm Beach and Fort Lauderdale may send a clear signal of intercity rail’s capacity to revitalize a district. Land values in those downtowns are much lower than in Miami—so the value of AAF’s projects there may be easier to quantify.

Expect the rest of the rail world to watch those neighborhoods carefully. In the end, any corporation trying to imitate the financial architecture of the AAF project, with its ambitious, integrated, multicity approach, would need an understanding of whether downtown rail stations were truly causing real-estate surges. Is this a project that can be replicated between Houston and Dallas, or Los Angeles and San Diego?

It's a familiar puzzle for those who study growth and development in cities. There's no prism to split the white light of a vibrant downtown into its various components, isolating the influence of transit from long-term demographic trends, local politics, and the general revival of urban America.

Looking south down NW 1st Avenue, with All Aboard Florida's nine-acre Miami plot at the right. HENRY GRABAR

All Aboard Florida may well be a success. But will it be an example? 



PART 3

DESIGN IN MOTION

Innovations in design, technology, and planning that will alter America's transportation landscape.

Why Portland Is Building a Multimodal Bridge That Bans Cars

The first of its kind in the U.S., the Tilikum Crossing will reflect the city's enduring transit culture.

BRIAN LIBBY | *Originally published August 19, 2014*

PORTLAND, Ore.—It's an early-summer morning at the construction site for Portland's first new bridge in a generation, the [Tilikum Crossing](#), and Dan Blocher is feeling good about its progress. Completion is still a year away, but since the two ends of the bridge were connected in the middle several weeks ago, public response in self-described Bridgetown (when it's not, say, the Rose City, Stumptown, or Rip City) has been positive.

The car-free Tilikum Crossing is being hailed the "bridge of the people." COURTESY TRIMET



“Most people can sort of viscerally recognize an inherent beauty when the bridge is properly designed for its need,” says Blocher, executive director of capital projects for TriMet, the city’s transit agency. “I think you know when you’ve got it right, when the completed product just seems to fit, just like it belongs there. And we feel very good about the feedback we’re getting on this bridge now that you can see what it’s going to look like.”

As we stand along the banks of the Willamette River, where workers are toiling both above us, on the recently completed deck, and below, in small boats where the footings meet the water, Blocher points to a number of the bridge’s unique design features. The H-shaped towers are smaller than those of most cable-stayed bridges, for example. That’s because Tilikum threads single cables up through the towers and down again to the deck, rather than using two sets of cables connected separately to the tower. The bike and pedestrian paths on either side jut out in the middle, he says, to reduce wind drag. The angle of the white cables is meant to recall the triangular form of Mount Hood, standing tall in the distance and visible from the bridge.

Though cable-stayed bridges such as these are common, perhaps even ubiquitous, the design, by San Francisco’s Donald McDonald, is smaller and more slender than most multimodal bridges, with a kind of jazzy, kinetic energy to its triangular forms. Looking up at the bridge in the morning light, I can understand Blocher’s reference to a similarly framed but better-known image, from the movie *Manhattan*: a black-and-white shot of Woody Allen and Diane Keaton sitting before the Queensboro Bridge.

Yet within a few seconds, Blocher stops himself, with a kind of prideful admission. “It’s an act of urban planning, maybe even more so than a transit project,” he says. Tilikum Crossing is the nation’s first multimodal bridge that will be off-limits to private automobiles. It will carry MAX light-rail trains (the impetus for the construction) as well as Portland’s streetcar line and city buses, and of course pedestrians and bikes in designated lanes on both sides—but no cars. If the bridge looks elegant in its slenderness, that may be because the omission of private automobiles keeps it from taking on a more gargantuan array of lanes and entry/exit ramps.

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Portland has long been known for this kind of compact, pedestrian- and transit-oriented planning. In the early 1970s, the city rejected a plan recommended by consultant Robert Moses to build an east-side freeway after a spirited citizen campaign against it; instead, federal highway funds were used to build Portland's first light-rail line, MAX (for Metropolitan Area Express), one of the [first such lines](#) built in the United States since before World War II. In the 1980s, a multilane downtown thoroughfare along the Willamette River was removed to build a park. The city was among the first in the late 20th century to bring back streetcars.



A rendering of the Tilikum Crossing, designed by San Francisco's Donald McDonald. COURTESY HNTB

This stretch of river also has long reflected America's changing economics, as well as its attitudes about city-building. As we watch the Tilikum Crossing construction that morning, Blocher recalls seeing a photo from 1964 showing the west side of the Willamette at this site. Back then, the river was lined with decommissioned "liberty ships" from World War II, while a massive bridge for the new Interstate 5 freeway, the Marquam, was under construction.

The reason for excluding cars at Tilikum Crossing was not a desire to pioneer or make a statement but rather a more practical reality. "What makes this one so unique is basically because it's a product of its environment.



This 1964 photo of the west side of the Willamette River shows a massive bridge for the new Interstate 5 freeway, the Marquam, under construction (upper right). CITY OF PORTLAND ARCHIVES

There's not a road network at either end of it," Blocher explains. "Plus, we have this great redevelopment happening on both sides of the river, and we're going to carve it up with freeways on both sides? That's kind of a nonstarter."

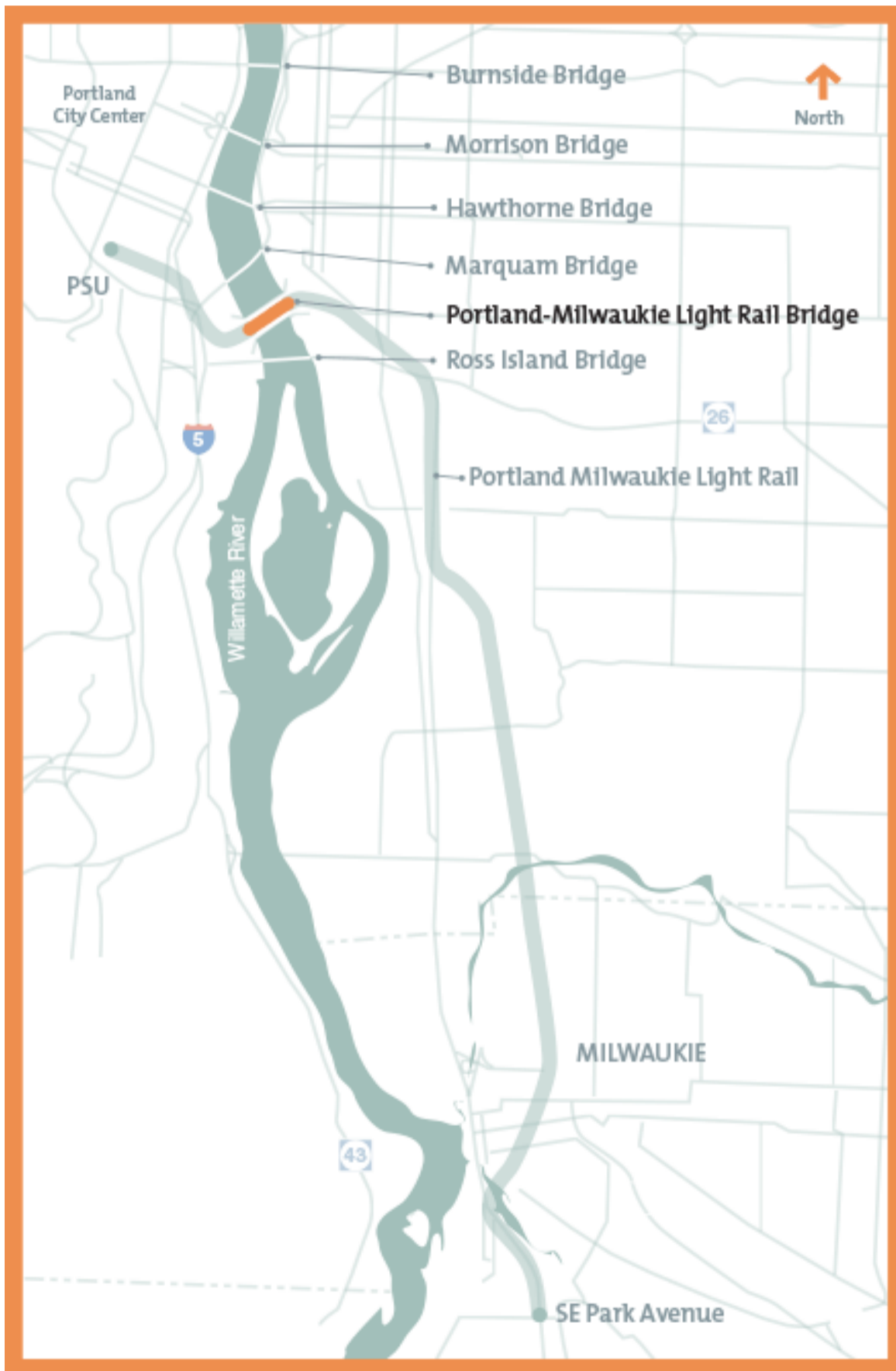
Rather than building any new bridge, the cheapest option would have been to put MAX on the existing Hawthorne Bridge, although its century-plus age and frequent drawbridge lifts would have been problematic. Instead, the agency worked in close collaboration with City of Portland planners to span the river diagonally, southwest to northeast, so that the west bridgehead would serve the burgeoning South Waterfront district. Tilikum Crossing may be about moving light-rail, but it's just as much about creating connections between new close-in 21st-century neighborhoods.

A map of Portland bridges, with the Tilikum appearing under the name Portland-Milwaukie Light Rail Bridge. COURTESY TRIMET

Situated on a long, thin former brownfield site along the Willamette River that's hemmed in by Interstate 5, South Waterfront has clusters of tall condos and medical buildings that sprouted during the prerecession real-estate boom. Yet it was not merely a get-rich dream for private developers. The district is the centerpiece of Portland's (and Oregon's) ongoing effort to curb sprawl by increasing density on existing close-in land,

much of it formerly industrial. Besides the condos, South Waterfront and the adjacent Zidell Yards (former shipyard land) are becoming home to a new riverfront campus for Oregon Health and Science University. While the freeway is close by, it can only be accessed in one direction, and most of South Waterfront thus feels disconnected from the broader downtown street grid. The district needs mass transit to flourish, which is why Portland extended both streetcar and light-rail lines there in addition to the [Portland Aerial Tram](#) (only the nation's second aerial commuter tram), connecting OHSU's hillside main campus with its new buildings along the water.

There was a time during the depths of the Great Recession when numerous South Waterfront condominiums were subject to foreclosure and high vacancy, but along with the return of the real-estate market, the presence of Tilikum



Crossing is helping to transform the district by connecting it with the rest of the city. That connection couldn't have been accomplished with new roads, because I-5's configuration wasn't going to change and the east side of the bridge is already filled with rail yards. TriMet and city planners realized a transit bridge was the best solution.

Besides the mix of high-density housing and the biosciences campus occupying the river's west side, the east side where Tilikum Crossing touches down is also being eyed for future development. Although the Central East-side district just north of the bridge is a protected industrial enclave—albeit increasingly home to creative-class workers in skinny jeans more than light-industrial workers in Dickies—the acreage around the bridge near the Oregon Museum of Science and Industry is being rezoned as another high-density pocket of commercial and residential development. This will be part of the city's "innovation quadrant" that links west-side institutions like OHSU and Portland State University with the east side's OMSI and Portland Community College. In boom or bust, transit and planning have been in lockstep.

"I think transit agencies have to have an urban-planning instinct, because they're about moving people around in some way other than a car," says Guinevere Millius, who heads the city's all-volunteer Design Commission and was part of Tilikum Crossing's advisory committee. "Transit has a huge impact on urban planning. I mean, if you look at our city, it was designed around streetcars. On some level, it has to be part of their DNA." Millius says the transit culture goes back to Portland's anti-Moses sea change in the early 1970s. "I think that original decision to turn down federal dollars for a freeway and instead to invest that in MAX, that's a fundamental shift that other American cities don't make," she says.

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Although Portland had practical reasons for excluding private automobiles from the bridge, Tilikum Crossing nevertheless seems to tell a broader national story: of heretofore mostly industrial waterfronts transitioning to public use; of an industrial economy transitioning to high tech and health care; and of more workers finding alternative means of getting to work.

“They’re looking to the future and saying maybe automobiles were a big part of our past development, but going forward we’re going to need a mix and a balanced system,” says Art Guzzetti, vice president of policy for the American Public Transit Association. “As cities grow, their ongoing growth has to have transit. Automobile growth tends to be more spread out, and you can’t spread out forever. Transit is more efficient from an urban-development point of view. An urban core designed around transit can use about 9 percent of its land for streets and roads. A more auto-oriented area can use as much as 35 percent.”

Tilikum Crossing, shown here in April 2014, is expected to open in fall of 2015. COURTESY TRIMET

Dan Blocher and TriMet take pride in the high degree of public involvement that occurred throughout the Tilikum Crossing planning and design process, including a citizen advisory



committee led by former Portland mayor Vera Katz. But the process wasn't without friction. TriMet upset Portland's design community, and even members of its own advisory committee, by choosing a ubiquitous cable-stayed bridge type over one proposed by Boston architect and bridge designer Miguel Rosales. Known for Boston's Leonard P. Zakim Bunker Hill Bridge over the Charles River, Rosales envisioned a bridge that would have been the first of its kind, combining suspension and cable-stayed types in a way that was perhaps more elegant while also referencing Portland's most beautiful span, the St. Johns suspension bridge a few miles north of the city center.


"It was a missed opportunity," says Millius. "I don't think TriMet has an interest in putting themselves out on a limb when it comes to design, and a lot of their projects kind of bear that out." Even so, she adds, Tilikum is "going to be a nice bridge, no question."

"They're looking to the future and saying maybe automobiles were a big part of our past development, but going forward we're going to need a mix and a balanced system."

Tilikum Crossing will be only a couple hundred yards from other bridges on either side, and McDonald's design minimizes tower height and span width enough to avoid seeming like the bridge is a large foot being wedged into a small shoe. Yet, while McDonald has a long track record that includes the new Bay Bridge connecting San Francisco and Oakland, Tilikum's attractive slender proportions also directly result from its lack of private automobiles. "It would be a lot wider if it had automobiles," says McDonald. "On bridges with cars, you have to have spaces to pull off. It'd be maybe twice as wide. The towers might have to go considerably higher."

In the distance beyond the bridge's construction site as we visit that day, Blocher and I can still see a host of highways and thoroughfares on both sides of the river and across it, carrying thousands of cars. If Portland is known for its mass transit, walkability, and bikes—the modes that will use Tilikum Crossing—it's still largely in relation to sprawled-out, car-centric fellow West Coast cities.

Yet bridges are symbols, and Tilikum Crossing seems to fit not only along its Willamette River spot but into the broader Portland narrative.

“It’s not for everybody,” says Blocher of transit ridership. “A lot of people like to drive their cars because of their scheduling needs or child-care needs or so forth. But for everyone who does ride the transit system, that’s a car off the road. It has to be looked at as a total transportation system. And Portland is really the poster child on the integration of land use and transportation planning. People come from all over the world to study how it’s done here.” 

If an Electric Bike Is Ever Going to Hit It Big in the U.S., It's This One

Is the Copenhagen Wheel poised to become the next big thing in alternative urban transportation?



MICHAEL D. SPENCER / SUPERPEDESTRIAN

NATE BERG | *Originally published July 29, 2014*

CAMBRIDGE, Mass.—On a sunny but brisk spring morning near the Charles River in Cambridge, I took a test ride on the bicycle of the future. No rockets or lasers (alas), the bicycle of the future looks pretty much like the bicycle of the present. But with the first pumps of my feet on the pedals, I felt the difference. The bike wasn't just moving, it was *pushing*, adding extra propulsion to my own pedaling, giving me a boost with every revolution of the pedals. Faster than expected, I reached the end of a quiet block and leaned

into the corner. I took a straightaway for a few blocks and pushed 20 miles an hour without hardly trying. My feet were putting in a solid paper-route effort, but the bike had me racing in the Tour de France.

The bike I tested was equipped with the [Copenhagen Wheel](#), an electric pedal-assist motor fully contained in the oversized red hub of an otherwise normal back bicycle wheel. Inside that red hub is a delicately crammed array of computing equipment, sensors, and a three-phase brushless direct-current electric motor that can feel the torque of my pedaling and add appropriately scaled assistance.

Replace the back wheel of any bike with the Copenhagen Wheel, and your bike is instantly an electric bike—one that not only assists the rider but senses the surrounding topography and can even collect and share data about environmental, traffic, and road conditions. First developed in 2009, through a partnership between MIT's [Senseable City Lab](#) and the City of Copenhagen, the wheel is now in its first stages of commercial production. By the end of 2014, thousands will be shipped out to fulfill preorders from around the world.

With its focus on design and simple application of complex technology, the Copenhagen Wheel is perhaps the sleekest version of the electric bike. But it's hardly the only one. Millions of electric bicycles are being used in cities all over the world, offering cheap and accessible forms of transportation in developing countries and dense urban environments. And though bicycling has long been considered recreation in the United States, the electric bicycle is about to become the next big thing in urban transportation.

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The electric bicycle is a relatively new idea. In its basic form, it's a battery-powered motorized bike operated either by a manual throttle on the handlebars or by an automatic system that adds power when the rider is pedaling. About 20 years ago, manufacturers began to offer these lighter and cheaper alternatives to mopeds and motor scooters.

Frank Jamerson has been watching the market evolve since the beginning. An engineer who helped build the first nuclear submarines at Westing-

house and who later helped run the EV-1 electric-vehicle program for General Motors, Jamerson started publishing the [Electric Bikes World Report](#), a biannual profile of the global market for electric bikes, in 1995. Then, as now, China led the way, according to the report's co-author, and chairman of the [Light Electric Vehicle Association](#), Ed Benjamin.



China was an early adopter of electric bikes and still leads the world in sales, with 32 million in 2013. [2 DOGS / FLICKR](#)

Benjamin and Jamerson estimate that 32 million electric bikes were sold in China in 2013, though they note that the Chinese bikes are often low quality, costing a few hundred dollars on average and only lasting for a year or two before breaking down. In Europe, the next biggest market, where most of the electric bikes are higher quality and sell for upwards of \$3,000, Jamerson and Benjamin estimate about 1.4 million sales in 2014. Japan and India are other major markets, with sales in the hundreds of thousands.

In the United States, the numbers are smaller but growing. From July 2011 through June 2012, American consumers bought about 100,000 electric

bikes, according to Jamerson's estimates. The next year, sales reached 185,000. By 2016, as more manufacturers and retailers get into the electric bike market, Jamerson expects annual sales to exceed 400,000. Within 20 years, he thinks, the number could be as high as 2 million, and the United States will be one of the top markets for electric bicycles in the world.

"We've got an ever-expanding population in the world that's moving more and more to denser and denser cities. Those cities require transportation solutions much more like a bicycle or an electric bicycle," says Benjamin. "The fact that the United States is transitioning a little bit slower than the rest of the world, I don't see that as important. It's going to happen. It is happening. It will continue to happen."

There's certainly no shortage of manufacturers. There are nearly 100 brands of electric bikes currently on the market. From Chinese manufacturers building millions of electric bikes a year to small garage-based start-ups, the

supply side of electric bikes has developed rapidly over the past 20 years. And though Chinese [manufacturers like Geoby](#) are leading the global market, much of the U.S. market is led by three American companies: Pedego, Prodecotech, and Currie Technologies.

Currie, based in Simi Valley, California, has been building electric bikes since 1997. The company now offers more than two dozen different types of electric bikes, ranging from beach cruisers to mountain bikes, as well as a variety of conversion kits. Currie's president, Larry Pizzi, concedes that the U.S. market has been slower to develop, but says he's also seen

recent strong growth in sales. Without offering specific figures, he says sales were up 25 percent from 2011 to 2012, and another 25 percent from 2012 to 2013. And the trend is continuing upward: Pizzi says business with dealers "more than doubled" through the first quarter of 2014.

But retailers have been slow to adopt electrics as a viable product—especially in the United States. Pizzi says retailers have been hesitant because elec-

Within 20 years, experts believe the United States will be one of the world's top markets for electric bicycles.



tric bikes run “counterintuitive” to what they think their customers want. “It’s a passionate industry in North America, and it focuses on the enthusiast core,” he says. Think weekend century rides and skintight outfits. “That’s all well and good. But they’re not thinking about bikes for transportation.”

The [shift is happening](#), although slowly. Jamerson says that of the roughly 4,000 bicycle-specific retailers in the United States, about 900 sell electric bikes today. And some of the world’s biggest vehicle manufacturers and technology companies have plans to enter the U.S. market, too. Smart [recently began selling](#) pedal-assist electric bicycles in its U.S. car dealerships, [as did Ford](#). The German engineering and electronics company Bosch has made major investments in [electric-bike drive units](#), which are now used by more than 60 different brands. Industry insiders say General Motors will likely be entering this market soon as well.

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The bike of the future that I rode in Cambridge, equipped with the Copenhagen Wheel, also had an iPhone mounted on the handlebars. I swiped my finger across it to switch from Turbo mode to Regular, bringing my top speed down to about 15 miles an hour, according to the phone’s display. I pedaled normally, but didn’t exert myself. When I stopped pedaling, the motor stopped, too, and I coasted, which also recharged the battery. Once I started pedaling again the motor almost instantly kicked back in, boosting me forward with a subtle but noticeable push of extra power.

After riding around for a while, I took this prototype bike back to the offices of Superpedestrian, the company that’s been developing the commercial version of the Copenhagen Wheel. In a small conference room, whiteboards and white walls were covered in drawings of gizmo components and schematic printouts. Next to a hand-drawn sketch of the wheel’s internal parts, somebody had scribbled the words *puzzle building*.

Assaf Biderman, founder of Superpedestrian and associate director of the Senseable City Lab, from which he spun off the company, explained that the original idea for the Copenhagen Wheel had emerged in a class of about 10 students working on ideas related to a partnership with Copenhagen meant to develop urban solutions. Even with Denmark’s already high



Cyclists using the Copenhagen Wheel can change speeds by swiping a smartphone fixed to the handlebars. COURTESY OF SUPERPEDESTRIAN

rate of cycling, the city was looking for ways to get more people on bikes by understanding what was holding some of them back. The major factor was distance.

“We decided, instead of thinking about the whole bike, let’s think about where the crux of the matter here is, which is motorizing it and giving people access,” says Biderman.

They finished a prototype of the electric-assist wheel in time to unveil it at COP 15, the 2009 United Nations Climate Change Conference, held in Copenhagen. Mayors and government officials from around the world took it for a test ride. “The goal was to send world leaders home with a message that almost any city in the world could become as cycling-friendly as Copenhagen,” says Biderman. Back at MIT, the Senseable City Lab continued to develop the wheel, and Biderman licensed the idea from the university in late 2012. He quietly opened the Superpedestrian office in Cambridge and stocked it with engineers and roboticists who’d previously built vehicles

like UAVs (unpiloted aerial vehicles) and the Segway. In December 2013, they began accepting preorders, with the wheel priced at \$699. (It's now selling for \$799.)

One of the main principles guiding the design of the Copenhagen Wheel was that it should be incredibly simple. "The bike should stay a bike," says Biderman. Ease of use is certainly part of the appeal. Once installed, the wheel is operated by a smartphone app via Bluetooth. The wheel unlocks itself when the user's phone is close by, and the app includes several speed-assist settings, from Turbo to Flatten My City, which uses sensors in the hub to detect hills. The wheel imitates the rider, integrating its own propulsion seamlessly as the rider pedals: pedal more, get more power; pedal less, get less. Braking and coasting recharge the lithium-ion battery, which holds about 30 miles of range. To facilitate global use, the Copenhagen Wheel's specifications can be altered to comply with local cycling regulations for wherever it's sent.

From the user perspective, the wheel is simple. But inside it's literally a robot computer. Many sensors and control algorithms are working constantly to understand the motion of the bike, its position in space, the torque of the rider, and the additional torque it must use to achieve the desired speed. Superpedestrian has also created an open programming interface, enabling developers to make their own modifications to the app and its interactions with the wheel. Of the preorder group, about 20 percent of buyers self-identified as programmers and have volunteered to provide feedback on how their hacks work with the first iteration of the wheel.

Initially the design included a number of other environmental sensors and sharing capabilities that would turn the wheel itself into a sort of roving urban sensing unit. Ideas included carbon-dioxide and noise sensors, and an option to collect road-condition and traffic data that could be sent to a database for the city's use in addressing dangerous streets or adding bicycle infrastructure where ridership is high. For now, that's been set aside to get the first version finished at an affordable price; more sensors cost more money, after all.

Biderman says some of that may come later, but it all depends on how people want to use the wheel. Ultimately, he expects to see some ways of col-



The Copenhagen Wheel (above, in red) can turn any bike into an electric bike. MICHAEL D. SPENCER / SUPERPEDESTRIAN

lecting and sharing data widely (and anonymously), from neighborhood cycling communities to city hall.

“I think there’s a very exciting future for planners and local governments when it comes to being able to address demand in a quantitative way and a rigorous way based on real usage,” he says.

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Americans have a mental block about bicycling that’s mentioned again and again by industry insiders: while people in places like Europe think of [bicycling as transportation](#), people in the United States largely still think of it as recreation. There’s a long history of urban-development patterns and transportation policies that have led to this perception, and those tendencies are hard to break. Though there does seem to be a general uptick in cycling in pockets of the country, the reality is that most U.S. transporta-

tion happens in a car. If the electric bike is to be successful here, it will have to overcome the national perception of bicycles as toys.

Transitioning the bicycle from recreation to transportation could hinge on something [as simple as a sweaty armpit](#). “For 30 years, I’ve seen surveys about why people don’t ride,” says Andy Clarke, president of the League of American Bicyclists. “They don’t ride because it’s too far or because they get hot and sweaty. And these are things that electric-assist bikes can help overcome.”

A big way to open the market will be to make them more affordable. Even more important will be to make them cool.



A [recent survey](#) of U.S. electric-bike owners suggests some progress on the problem of the sweaty commute. John MacArthur of Portland State University found that 74 percent of the 553 respondents said they don’t need to shower after an average trip on their electric bike. But sweat, or lack thereof, isn’t the only thing pushing people onto electric bikes. According to MacArthur’s survey, almost 70 percent of respondents said they purchased their electric bikes to replace some of their car trips.

MacArthur notes that while his survey wasn’t the most scientific, it did reveal some interesting demographics about who is using electric bicycles. About 45 percent of respondents were 55 or older, and about 30 percent indicated that they have a physical condition that makes riding a standard bike difficult. He argues that these should be indications to retailers that the market for electric bicycles isn’t just made up of hip Millennials; older people are interested in them, too.

“I think the survey alludes to the potential that electric bikes really can get more people biking and to bike more often,” says MacArthur.

The international nature of the electric-bicycle market has posed some problems, too. Different countries have different standards for how fast and powerful electric bicycles can be. For example, electric-bike motors in the European Union can be only 250 watts, while in the United States they

can be up to 750 watts. China allows a top speed of about 12 miles an hour; the EU, about 15 miles an hour; the U.S. and Canada, 20 miles an hour.



Assaf Biderman, founder of Superpedestrian, says the goal of electric wheel-assist design was to make almost any city "as cycling-friendly as Copenhagen." [DYLAN PASSMORE / FLICKR](#)

Much of the confusion has to do with what, exactly, counts as an electric bike. Some places consider electric bikes and mopeds with internal combustion engines to be essentially the same thing, while others draw strong lines between them. Some places require helmets or registrations, while others don't.

The United States, for its part, has at least come up with a standard definition (put forth in [H.R. 727](#), an amendment to the Consumer Product Safety Act that became law in 2002). Even with federal guidance, confusion remains. State and local regulations of electric bicycles vary widely across the country, especially with regard to whether they [belong in car or bike lanes](#) (or both). "Some municipalities and states are more equating electric bikes

with the bicycle, and others are more equating them with a moped or motorized cycle,” says MacArthur. The inconsistency has led some places to restrict electric bikes from using bike lanes.

Clearing up the regulations will take time, and it may take more electric bikes on city streets. Though numbers are rising, the main challenge for electric-bike makers and evangelists is to make them mainstream. Convincing the U.S. market to consider electric bikes as transportation will be key, according to Benjamin and Jamerson, the industry trackers. A big way to open the market will be to make them more affordable. Even more important will be to make them cool.

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Superpedestrian has done the first run of production in the workshop of its Cambridge office, and is working on industrializing the process for factory production by the thousands later this year. The project is venture-capital-backed, and Superpedestrian has inked deals with a few undisclosed major international companies to get even more of the bikes on the road. The design and idea behind the Copenhagen Wheel has even inspired some competition. A very similar back-wheel pedal-assist add-on called [FlyKly](#) raised \$701,239 [on Kickstarter](#) in November 2013, and the company expects to ship its first wheels in the fall.

Benjamin, who works as an adviser to many electric-bike manufacturers, says he’s happy to see these new players get into the electric-bike market. They’re worlds away from the low-quality lead-acid-battery bikes he saw in China in the mid-’90s, and he thinks that these newer, sleeker, simpler electric bikes could finally help the U.S. bike market start thinking seriously about going electric. The Copenhagen Wheel is leading the way, he says.

“The Superpedestrian wheel is so far in the lead in terms of the engineering and coming to market that they are probably going to define the market entirely,” says Benjamin. “I’d say that on my list of customers that are going to hit a home run, that one’s at the top.”

But changing perceptions takes time. Jamerson, who’s been watching the electric-bike market since it first emerged, says electric-bike makers will

have to do all they can to take advantage of America's cycling momentum. He even suggests one of the oldest tricks in the marketing playbook: the celebrity endorsement. "We have not had enough pictures of celebrities riding electric bikes," he says.

He's got some ideas. He says that a few years ago, during a reception with then-Energy Secretary Steven Chu, a Chinese delegation gave electric bicycles to Chu and Barack Obama as gifts. If someone could get Obama to ride his electric bike, says Jamerson, that could really get them into the hearts and minds of the American public. "If you know anybody in the White House," he says, "tell them there's an electric bike somewhere in storage that they ought to pull out." 

The Next-Generation Airport Is a Destination in Its Own Right

Why the new Indianapolis terminal will be a model for others to come.



HOK

BONNIE TSUI | *Originally published August 26, 2014*

INDIANAPOLIS—Robert Chicas is old enough to remember when air travel was glamorous. Born and raised in New York, he flew PanAm with his parents every summer to visit family in Central America, via Miami. Everyone dressed up; he and his brothers wore ties, and the flight attendants wore gloves. Airports, he says, were all about the destination: they celebrated one's arrival in a place.

Nowadays, flying has more in common with mass transit. “It’s like riding the bus,” Chicas told me recently, with a wry note in his voice. But that might be changing. Chicas is an [architect for HOK](#), a global design firm with 23 offices around the world, and co-leads the company’s aviation and transportation practice from New York. He was project manager for the [Indianapolis International Airport Colonel H. Weir Cook Terminal](#), which opened to acclaim in 2008.

With views of the downtown skyline, the \$1.1 billion new Indianapolis airport [has been celebrated](#) for its [sense of place](#), and for treating travelers as “guests,” much the way the hotel industry does. It has its own civic plaza, a light-filled central space with 35-foot ceilings that functions as the nexus of activity—every passenger, whether arriving or departing, passes through—where half of all the airport’s shops and restaurants reside. Customers routinely comment on the terminal’s calm feel, and on its efficiency and easy navigation. Though Indianapolis is a small city (population 843,000, [but growing fast](#)), it hosts what Chicas calls “the equivalent of three to four Super Bowls a year”—major sporting events like the Indy 500, the NCAA Final Four, the NFL combines, and, in 2011, the [actual Super Bowl](#).

But even as passenger traffic balloons for these occasions, security checkpoints here are rarely clogged. What is Indy doing right?

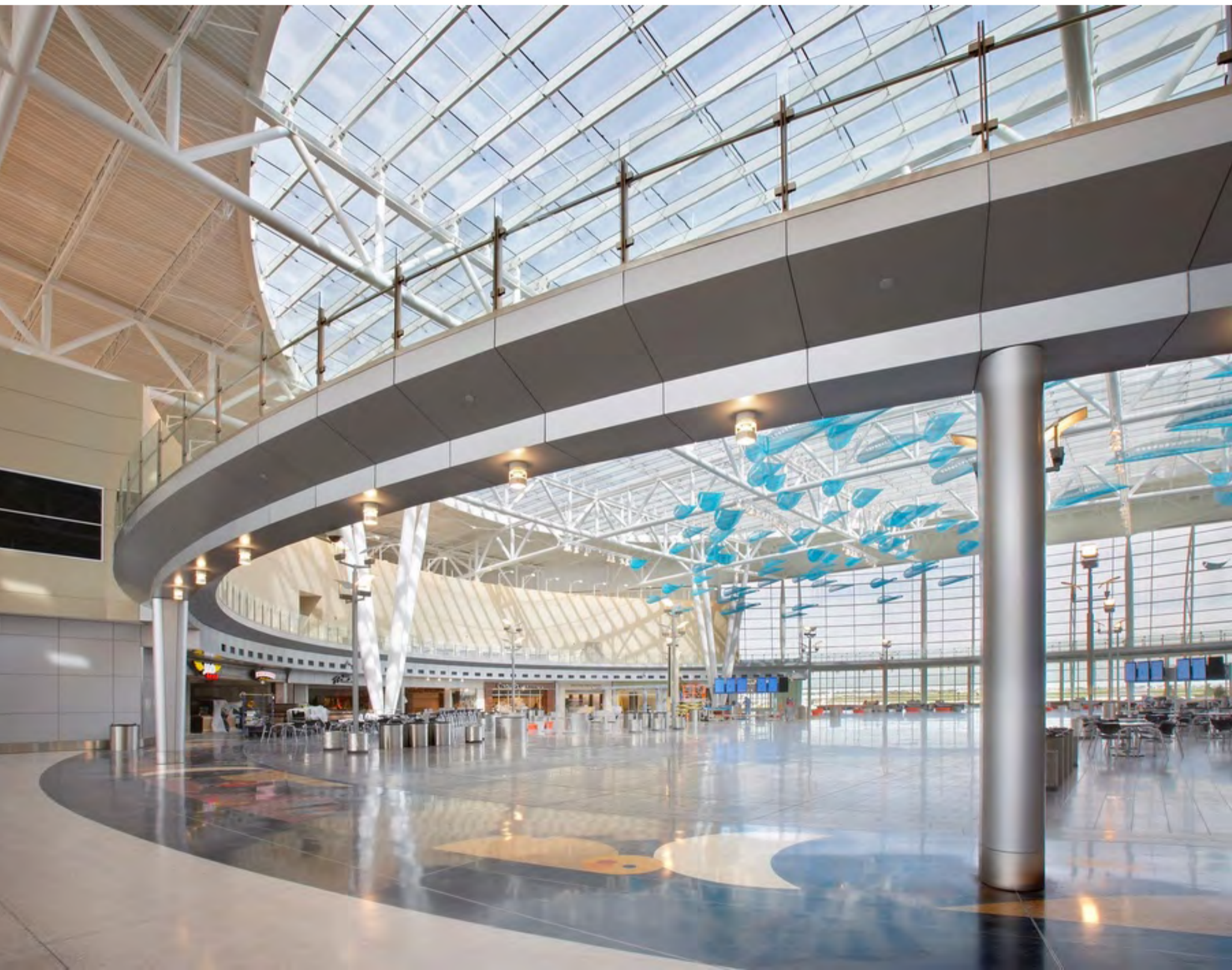
Next-generation airport design is increasingly focusing on the airport as a destination, instead of just a thoroughfare. We spend so much time in airports now—so much more than we did in the past, due in large part to security changes in the post-9/11 era. Architects are revisiting how to make airports friendlier places to spend that time. But smart design also needs to assess the complete experience from end to end, taking into account how easy it is to check in online, say, or how reliable public transportation is in and out of a city. In other words, the ideal guest experience shouldn’t end when guests leave Point A—it needs to cover Points B, C, and D, too.

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An airport’s having a sense of place is no different from the idea of any other form of architecture. Think of an iconic museum or a beloved sports stadium: it feels rooted in the community it serves, and brilliantly repre-

sentative of the place it calls home. Many airports are gateways to major international cities or regions, and they vary dramatically in their character, says Richard Gammon, HOK's global director of aviation and transportation. He is spearheading the expansion of [King Khalid International Airport](#) in Riyadh, Saudi Arabia; HOK is also behind high-profile airport [projects in Doha](#), New Delhi, Boston, and [Salt Lake City](#). "As big civic buildings, they're often used as a way of expressing pride in a state or nation or city," Gammon told me. "We see that throughout the world. In the Middle East and Asia right now"—from Dubai and Doha to Shanghai and Beijing—"every major airport is a status symbol trying to demonstrate the wealth and power of its state." In the United States, they're more about being the gateway to the city, state, or region, but the desire for design to represent characteristics of place still holds true.

HOK



Still, plenty of airports give the feeling that you could be anywhere. It's the kind of utilitarian, no-frills experience that sucks the joy out of traveling to a new place. But why? Gammon says this is the legacy of our aging airport infrastructure. Back in the 1960s, when air travel was taking off, North America and Europe saw a massive boom of airport development. Though a handful of these airports were distinctive, the vast majority were faceless, functional boxes, focused on processing passengers as quickly as possible. As capacity jumped in the switch from tiny propeller planes to big jets that hold 300 people, crowd management became the big concern. "The entire airport model as we know it grew and developed at that time, and because of how airports are funded, it doesn't allow for frequent demolition and rebuilding," says Gammon. "We're dealing with that legacy now."

Take Indianapolis. For many years, Indianapolis was a center of the automotive industry, but like other Rust Belt cities, it faced a steep economic decline in the 1970s. In the past two decades, the city has seen tremendous revitalization, particularly in the tech, life sciences, and pharmaceutical industries (Eli Lilly is a major employer) and in sports and convention business. It's also a [national hub for FedEx](#). Before 2008, though, it still had what Robert Chicas calls a "miserable little airport."


The city's mandate to HOK was to design an airport that reflected not what people believe the city is all about (cars, sports, farming), but what it aspires to be: a vibrant, high-tech metropolis that is a gateway to the Midwest. Chicas

says the airport's design and construction involved the city government as much as the airport authority. "They wanted a striking, tectonic piece of architecture that could be an icon for the city, which was a really interesting charge for us," he says. The airport, then, was more than a place for travelers to pass through. It was a chance for the city to rebrand itself.

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Does it succeed? In some sense, it already has; Indianapolis International Airport (airport code IND) was completed on budget, and is

The airport was more than a place for travelers to pass through. It was a chance for the city to rebrand itself.



the world's [first complete airport campus](#) to receive LEED certification. But to find out how it rated on passenger experience, I flew there from Dulles International Airport outside Washington, D.C., where the drab, low ceilings and fluorescent lighting of the United concourse conjured up a regrettable stay in an office cubicle, and the only concession to location was a sign indicating the imminent arrival of an America-themed souvenir shop. Not the ideal representation of the nation's capital, I'll wager. As a first-time visitor to Indy, I decided I'd let the airport tell me its story.

What struck me as an arriving passenger: the openness of the terminal and the relaxed posture of passengers waiting to board. It was the weekend of a major motorcycle race at the Indianapolis Motor Speedway—many hotels were booked solid—yet airport activity was well under control, with plenty of staff at gates and security checkpoints, and lots of seating in all areas. Floor-to-ceiling glass walls looked out onto the airfield; at intervals, brightly colored stained-glass panels had been installed with poetry inscribed on them. The pieces gave the airport the feeling of a tranquil, modern museum.

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Because Indianapolis prides itself as a city of the arts—it has the [largest children's museum](#) in the country, and the Indianapolis Museum of Art has significant holdings spanning 5,000 years—artwork is a major feature of the airport. A \$4 million public art collection was integrated into the bones of the terminal as well as in [a terrazzo piece](#) that rings the entire civic plaza. Some of the largest and most detailed pieces of art hang at the two security checkpoints, “where people dwell the longest,” Chicas told me.

Security areas have high ceilings and move passengers toward expansive panoramas of the airfield, so people going through can see the tails of aircraft parked at the gates. “You see what’s coming, and there’s a sense of orientation. Indy is a case study in that. If passengers know where they are, and know where they’re going, it helps relieve the anxiety of the whole experience,” explains Chicas. Uncertainty [plays a huge role](#) in passenger frustration, so the psychology of next-generation airport design focuses on creating calm. The natural lines of sight to the planes put people at ease, and are designed with intuitive wayfinding in mind. “A calm and unstressed passenger is a happy passenger,” he says.

In many airport terminals, your path depends on whether you’re arriving or departing. In Indy, all passengers move through the civic plaza, a kind of main living room where they can hang out, shop, eat, or just walk around. There is plenty of seating in public areas outside of restaurants, bars, and cafés. I sat with a glass of wine, watched one young woman do laps around the circular perimeter while pushing a stroller and chatting with her mother, and observed a guy eating a sandwich and having a beer while charging his phone under the bar. (The obligatory purse hook now has an outlet to go with it.) Little kids stood glued to the glass, watching the planes, while their parents relaxed on the couches behind them. People were actually *smiling*.

“About half of the [retail] outlets are locally owned and operated, and they sell items that are iconically Indy,” Carlo Bertolini, a spokesperson for the airport authority, told me. One store offers items from eight area museums and cultural institutions; downtown restaurants have a presence, too. “They’re consciously geared to make the airport an enjoyable destination in itself.”

Two women arrived at the center of the plaza with their rolling bags, looking puzzled. I’d counted five beats when they found where they needed to

go (the security checkpoint for Concourse B) with just two glances. One sign in particular struck me as genius: a map of the entire airport terminal, [marked with walking paths](#) and the distances of each leg. Why walk aimlessly when you can feel like you're accomplishing something?

As a frequent traveler, I find that the best airports offer activities people would like to do outside of airports. People aren't spending hours at the airport because they want to—they're doing it because they want to go somewhere else. So if you can take advantage of things that don't make you feel like you're wasting time—free Wi-Fi, good local restaurants, pretty things to look at, a comfortable place to sit or work, a museum-quality gift shop, a spa or gym—a long wait or a layover or a delay isn't all that bad. As Chicas put it, instead of waiting in a traditional "hold room," you could be sitting at a wine bar. "I like to think of it as 'enhanced waiting,'" he says.

And a nice ambience, with leafy plants (greenery is [known to be restorative](#)) and daylight ([ditto](#)), helps seal the deal.

It's the non-aeronautical revenue that's become critical to an airport's survival.

Of course, high-quality amenities aren't just about aesthetics: revenue potential is a powerful driver for 21st-century airport design. Given limitations on aeronautical revenue—airlines pay service fees to bring their planes in and to use the facilities, but the pressure is on every airport to minimize those fees to attract air traffic—*non-aeronautical* revenue has become critical to an airport's survival.

The lack of public money going into airport development, especially in the United States, means private businesses are the ones that invest in an airport—running retail shops, opening food concessions, operating rental-car agencies and parking lots, and deploying other creative methods for earning money from passengers.

"Simply landing planes and servicing them is not profitable," says HOK's Richard Gammon. "Treating the passenger as a guest, looking to the hospitality industry for clues to how to make the experience as individual as possible, completely tailoring the airport, physically and electronically, to bring the whole travel experience to a new phase—it's all driven by how to

profitably operate airports.”

Thus far in Indy, this strategy has been a good bet. “The airport supports the city as a gateway of economic growth,” says Carlo Bertolini. “IND generates an annual economic impact of more than \$4.5 billion per year for Central Indiana, including the support of approximately 21,000 jobs—all without relying on any state or local taxes to fund its operations.” And given its high customer satisfaction—Indy routinely tops polls as the [best airport in North America](#)—the airport will likely continue to attract business for the city.

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Gammon and his HOK colleagues stress that airports don’t need to be rebuilt from scratch to be improved. Take a big legacy airport like JFK in New York. JFK consistently performs [poorly in passenger satisfaction](#); it’s disconnected and fragmented, the individual terminals are dingy and cramped, and there’s a general lack of amenities. Worse yet, it’s a pain to get there; travel time is a question mark whether going by subway or taxi. Given the space constraints, rehabilitating old multiterminal airports like JFK is a challenge, and piecemeal changes are a given. But there are steps that can be taken.

Take bag processing, says Gammon. He estimates that 35 to 50 percent of any airport terminal’s infrastructure is solely related to that job—using prime airport real estate that could be given over to travelers. “How do you increase the processing capability of a space-constrained terminal? You take out the non-passenger-based functions,” he explains. “Even in existing terminals like a JFK or an SFO [San Francisco International], you could put other facilities out on the airfield to process bags.” The goal is to relieve travelers of checked bags early on, moving luggage to nearby facilities and leaving the terminals to focus solely on passengers; in Hong Kong, for example, air travelers can [check bags downtown](#), then board an express train to the airport.

If the future of air travel is to make the passenger experience as elegant, seamless, and efficient as possible, “liberating the terminal” makes a lot of sense. Right now, one of the biggest determining factors of customer satisfaction is how long passengers [have to wait for bags](#) or boarding passes (15




"Every major airport is a status symbol trying to demonstrate the wealth and power of its state," says HOK's Richard Gammon. Above, renderings of airport expansions in Riyadh (top), Doha (middle), and New Delhi (bottom). HOK

minutes seems to be the tipping point). New technology can eliminate both issues: high-speed conveyer systems can transport bags more quickly even as the bag facilities move farther away, and digital boarding passes have already expedited the ticketing process.

In fact, technology is the biggest visible influence on the airport experience, and the overlap of information technology and architecture is only growing. Chicas often reminds clients that in the electronic age, many people haven't gone to a physical check-in counter in years; their flight experience begins the minute they pull up the airline's website. If that interface is well designed, with screen-accessible information about flights, gates, and boarding that allows people to move through public-transit systems and the actual airport space more efficiently, then their trip is off to a good start.

Huge investment is being put into different forms of security screening—the worst part of a slog through the airport. Imagine walking through a lane, with remote devices scanning you and your bag: no need to stop moving to remove your laptop or shoes. Technology is likely already there. But with heightened tensions around aviation security, Gammon reminds me, changes will take time—in this arena, the priority is safety, not passenger convenience.

No matter what the specifics, designing a great airport for how we fly in the future is governed by one thing: recognizing what we don't know. Every smart new airport terminal is a framework that can flexibly adapt to changes that are coming, with fewer columns, higher spaces, and strategically moving parts. In Indianapolis, fixed elements—those parts of a building that can't be easily moved, which include elevators and mechanical shafts—are organized in neat, specific bands. Everything else—waiting rooms, concessions, restrooms—are boxes within boxes, and can be moved around or scaled up or down to accommodate new demands. “Check-in halls are getting smaller, security areas are getting bigger,” Chicas told me. “What do you do with them? You have to figure in unanticipated developments in what is a very fluid industry.” In other words, we know what we know. Smart design is planning for what we don't. 

PART 4

POLICY IN PERSPECTIVE

America's Cities Are Still Too Afraid to Make Driving Unappealing



DYLAN PASSMORE / FLICKR

Tough policies are the ones that would truly change commuter habits, but we're seeing few of them.

EMILY BADGER | *Originally published March 6, 2014*

The morning I wrote this, I took public transportation to work. I hopped on the bus around the corner from my house, then changed to the train for a few more stops. I took mass transit because it was convenient, because my fare card was already preloaded with the money that diverts from my paycheck, and because the ride gave me 20 minutes to start the day browsing Twitter.

Baked into this decision, however, were a number of other nearly subliminal calculations about the alternatives not taken. I did not drive the car (yes, my household has a car) because downtown Washington, D.C., is a hot mess at rush hour, and because parking near the office costs the equivalent of a fancy hamburger a day. I did not bike because it was snowing. ([Again.](#)) And I did not walk because the distance was too far.

My commuting choices—just like everyone’s—are the sum of the advantages of one transportation mode weighed against the downsides of all other options. Or, more succinctly: my feelings about the bus are mediated by what I’m thinking about my car.

At a macro level, this decision process implies that there are two ways to shift more commuters out of single-occupancy vehicles and into other modes of transportation, whether that’s biking, carpooling, walking, or transit. We can incentivize transit by making that option more attractive.

Or we can disincentivize driving by making it less so. What’s become increasingly apparent in the United States is that we’ll only get so far playing to the first strategy without incorporating the second.

“One of the things I keep looking at is cities like Boulder, Davis, and Portland—places well known for walking and biking,” says Daniel Piatkowski, a recent graduate of the design-and-planning doctoral program at the University of Colorado at Denver. I met him earlier this year at the Transportation Research

Board’s annual conference, where he was presenting on what he’s simply come to describe as the [“carrots” and “sticks”](#) that might be deployed to get people out of their cars.

“We’re still not seeing any really significant mode shifts, despite decades of investment,” he says, still talking about the cycling capitals of Portland and Boulder. “The crucial component that’s missing is that we’re not implementing any policies that disincentivize driving.”

“We’re still not seeing any really significant mode shifts, despite decades of investment.”

We can quibble over how to define “really significant” mode shifts. In Portland, the share of commuters who get to work by bike is about [6 percent](#), well above the national average (roughly [half a percent](#)). But Piatkowski’s latter point is unquestionably true: [relative to European cities](#), it is exceptionally hard in U.S. communities to implement real disincentives to driving.

There are ways to do it. We could reduce parking availability or raise parking rates. We could implement [congestion pricing](#). We could roll back subsidies for gas and highways and public parking garages. We could tie auto-insurance rates or infrastructure taxes to how much [people actually drive](#). All of these “sticks,” to use Piatkowski’s term, would have a real impact on how people choose to get around. And that impact would no doubt be larger than what we get from building new bike lanes, sidewalks, or bus stops.

But these are the options we almost never choose. For his research, Piatkowski looked at four cities that won grants, each worth \$25 million, to increase biking and walking as part of a federal [Nonmotorized Transportation Pilot Program](#). Unanimously, those cities spent almost all of their money on “carrots.” Piatkowski couldn’t even find much literature on the impact of driving disincentives in the United States because so few are implemented.

“On a scale of getting to a place that is like Zurich or Freiberg, one of these really epic walkable, transit-friendly, bikeable places,” he says. “We’re just so far away from that.”

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Piatkowski and his research collaborator, Wesley Marshall, aren’t arguing that cities shouldn’t deploy carrots like striping bike lanes or improving bus service or paving shaded sidewalks for pedestrians. After all, driving disincentives won’t be all that effective if commuters don’t have viable alternatives. More likely, they would just harm low-income commuters by increasing the burdens of driving without decreasing the burdens of alternative transportation.

The question is really how far we can get down the path of least resistance, pursuing only the politically easy tactics. If the goal at the end of the day is changing behavior, how much can you really achieve by showing people a

nice new bike lane?

“It’s going to be marginal,” says Marshall, an assistant professor in the College of Engineering and Applied Science at UC Denver. “You can’t expect to put in a bike lane and for it to be a magical elixir in most of the country.”

That’s not always the case. Carrot-like improvements to transit in New York City have [significantly changed behavior](#), because disincentives to drive are already built into the environment. New York is expensive and crowded, which means that parking is costly and congestion is bad. But elsewhere—in cities where driving is systematically subsidized in so many ways—the disincentives would have to come from more-explicit policy.

In the absence of such policies, Arlington County, Virginia, offers a good case study for the upper bounds of what’s possible with incentives alone. The county’s commuter-services office runs one of the most advanced travel-demand-management programs in the

country, just across the Potomac from Washington, D.C.

“We’re afraid to push the disincentive lever too hard.”



“The stuff we focus on is much more mundane, ground-level tactics,” says Chris Hamilton, chief of the county’s Commuter Services Bureau. “The [Bike Arlington](#) guys are just trying to help so many adults over the hump of riding a bike for the first time again.”

The county runs commuter stores and bike clinics. It teaches people how to swipe transit cards and find the bus. It coaxes building managers into putting bike lockers in the basement, and transit-information screens in the lobby. It prods local employers to subsidize transit cards and bike-share memberships.


Through all of this work, Hamilton’s office calculates that 42,000 trips a day in the county that would otherwise take place in a single-occupancy vehicle now occur in other modes instead. Three-quarters of those trips are taken by mass transit. All of that has come through lowering the barriers to alternative transportation or increasing the its appeal.

That's an impressive number. But when asked if he wouldn't rather the county just tax the heck out of parking, Hamilton laughs. He knows that would make his job much easier. "We wouldn't have to do any of this," he says.

A creative city might be able to make a disincentive feel like an incentive. Piatkowski points to a ["parking cash-out"](#) law in California that requires employers to give workers a cash allowance to not use parking.

"The stick then becomes missing out on the reward," Piatkowski says.

But why not just wield disincentives as what they honestly are? *Behavior change* sounds vaguely manipulative (whether we're talking about behavior involving automobiles or [thermostats](#)). But in this context, the disincentives are really about removing subsidies and distortions from the market. Parking [isn't really free](#). Gas taxes [don't actually cover](#) the costs of maintaining our roads. So why is it so hard to disincentivize driving at the same time that we incentivize the alternatives, at least until they're in some better kind of equilibrium?

"Because we're afraid," Hamilton says. "Because we don't have the guts to pull the levers on what we want. We know that we want a walkable, bikeable, transit community. We're building it. But we're afraid to push the disincentive lever too hard." 

The Next Century of Sustainable Communities Will Be Organized Around Transportation

The era of transit-oriented development and “networked livable communities” has arrived.



[MONTGOMERY COUNTY PLANNING COMMISSION / FLICKR](#)

JOHN L. RENNE | *Originally published April 29, 2014*

The Great Recession fundamentally changed the trajectory of both real estate and transportation in the United States. For the past century, our nation’s economy revolved around the production of vehicles, highways, sprawl, and more vehicles. Transportation policy emphasized a supply-side approach of building highways to increase the speed and mobility of our nation’s vehicular-based mobility system. However, in the 21st century,

transportation's focus will shift to managing existing infrastructure (as opposed to building new roads) and improving accessibility. This will be enhanced through transit-oriented development (TOD) and "networked livable communities."

As their name suggests, networked livable communities are networked into both the Internet and multimodal transportation systems. They're also networked into the professional economy: they are hubs and corridors of cafés, boutiques, restaurants, bars, and shared-office settings. They include art, live music, and animated street life. These communities are emerging in former warehouse and industrial districts, downtowns, historic districts, inner suburbs, TODs, college towns, and artistic communities that have bucked national trends over the past five years of eroding land values. As the saying goes, opportunities come from "being in the right place at the right time." Networked livable communities are the post-recession "right places." Residents there network for jobs, business financing, new partnerships, and overall professional connectivity.

Several interrelated events have set the stage for sustainable transport and the rise of networked livable communities over the next several decades. During the first decade of the 21st century, America's total vehicle miles traveled peaked. Since our transportation system is funded from the gas tax, the peaking of VMT means that we no longer have a growing source of federal funds to expand highways. The Great Recession also reduced suburban sprawl, which has lost favor with many Americans now looking to live, work, and play in denser, mixed-use areas. A [recent study](#) reported that close proximity to shopping and transit was important to the majority of Americans.

There is a pent-up demand for TOD, which is an important element in the success of networked livable communities. As a nation, we have built more than 4,500 fixed transit stations, most of which are on rail lines. However, only 38 percent of these stations areas achieve a minimum gross density of eight residential units per acre within a half-mile of the station—the level of density identified by researchers as needed to support transit usage. Density is also vital for business establishments to survive.

A study that I co-[authored last year](#) with Reid Ewing of the University of Utah reveals that TOD station areas have outperformed low-density [transit-](#)

[adjacent developments](#) (TADs) significantly in terms of sustainable commuting. TADs are the opposite of TODs; they are low-density, auto-oriented communities around rail stations that do not facilitate walking, or transit ridership other than via car access. In 2010, nearly 53 percent of commuters in TODs traveled by transit, walking, or bicycling, as compared to less than 16 percent living in low-density TAD station areas.

Perhaps surprisingly, TADs in the U.S. are wealthier on average than TODs, earning \$68,409 in household income compared with \$51,335. However, TOD residents spent only 37 percent of their income on the combined cost of housing and transportation; TAD residents spent about half their income on the same. In other words, the location efficiency afforded to TOD households yielded them significantly more in disposable income than TAD

households for the year. On average, TOD residents earn less but have about the same disposable income as their wealthier counterparts in TADs, who drive for most of their commute trips.


Given these findings, it's no surprise that over time TOD home values have significantly outperformed the national market, including TADs. The [TOD Index](#) reveals that from 1996 to 2013, homes in more than 449 TODs across the U.S. appreciated 325 percent, while

homes in 817 TADs appreciated about 200 percent—the same as the national market.

In sum, homes in TODs are worth more, which generates more local property taxes for cities. Residents spend less on housing and transportation costs, which means they have more money for other purchases from local businesses. The higher densities and higher share of non-car commuters means that transit agencies can earn more revenue by expanding TODs in vacant areas around stations.

As Americans demand more networked livable communities, cities can begin with increasing densities in empty areas around rail stations and incentivizing more TODs. Metro areas that build at eight units per acre

TOD residents spend less on housing and transportation costs.

(4,000 residential units or 10,000 people per station area) in all empty station areas could accommodate 26.4 million of the next 100 million Americans by 2050 in such locations. Much of the transportation infrastructure is already there, but local investments are needed around stations to unlock their potential. Local zoning reform is also paramount. Adding this density would go a long way toward enabling networked travel—including walking, bicycling, and other modes—and increasing overall accessibility for a sustainable transport system. 

Why Can't the United States Build a High-Speed Rail System?

The problem isn't geography, demographics, or money—it's federal will.



[DARKROOM DAZE / FLICKR](#)

YONAH FREEMARK | *Originally published August 13, 2014*

Virtually every wealthy nation in the world has invested in a high-speed rail network—with the striking exception of the United States. In [Japan](#) and [France](#), in even [Turkey](#) and [Russia](#), trains travel at speeds of 150 miles per hour or more, linking city centers and providing a desirable alternative to both air and automobile travel. Meanwhile, other than Amtrak's 28 miles of 150-mph track in rural Massachusetts and Rhode Island, the American rail network is largely limited to speeds of 110 mph or less. There are few reasons to think the situation will change much in the coming decades.

So why has the United States failed to fund and construct high-speed rail?

The problem is not political process. Most of the countries that have built high-speed rail are democratic, and have submitted the projects to citizen review; others, like Germany and Russia, have federated governments similar to ours that divide general decision making between levels of authority. Nor is it geography. The British and French completed a [31-mile tunnel](#) under the British Channel 20 years ago, while many American cities are located in flat regions with few physical construction obstacles. Nor is it the characteristics of our urban areas. While U.S. cities are less dense than those of many other countries, the Northeast is denser, more transit-reliant, and more populated [than most areas](#) served by high-speed rail abroad. Nor still is it money. Though the United States invests [less in infrastructure](#) than other developed countries do, America nevertheless remains an immensely wealthy nation perfectly capable of spending on new rail links if desired.

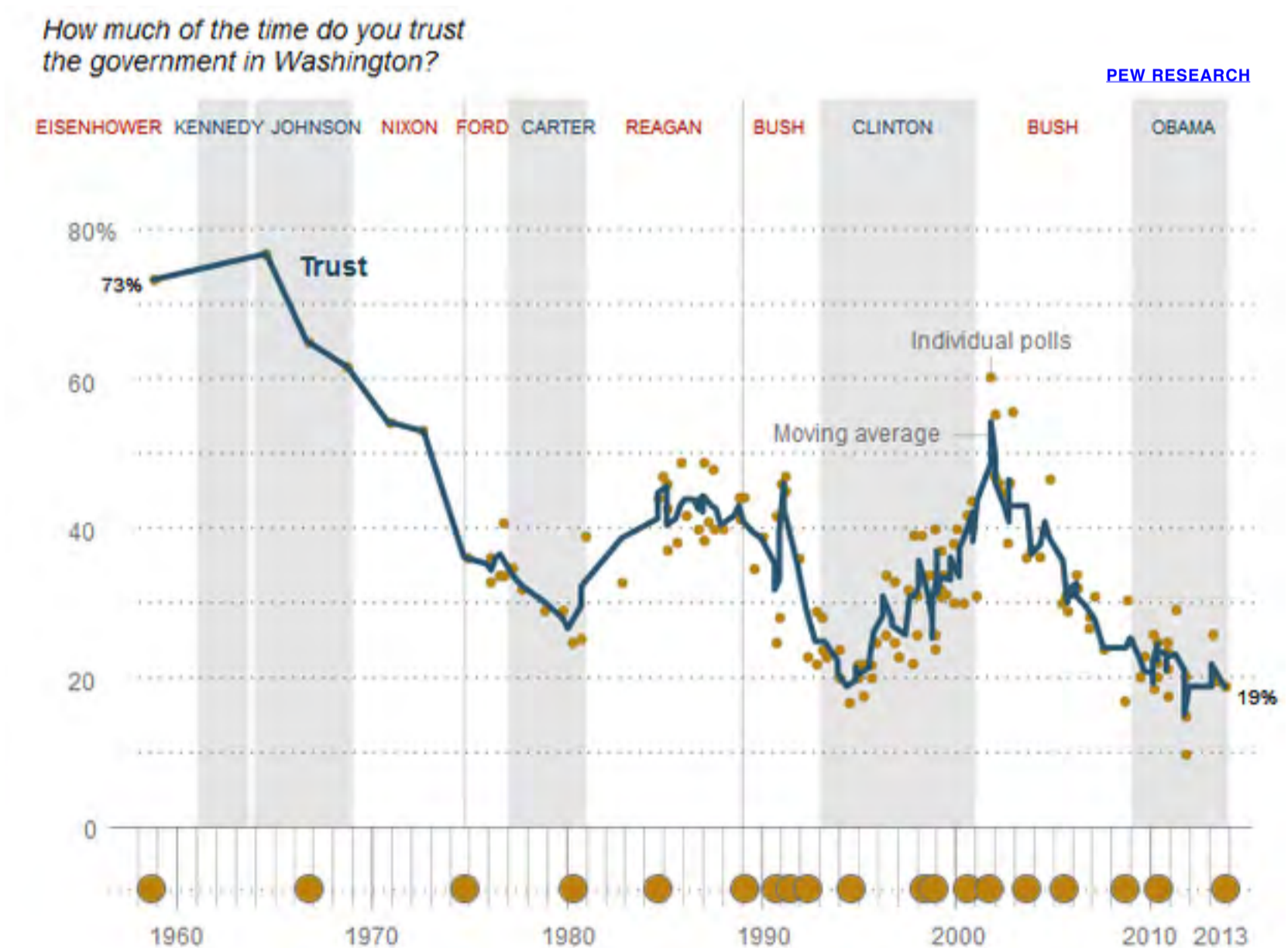
What's missing is a [federal commitment](#) to a well-funded national rail plan. Instead, we have a political system in which the federal government, having devolved virtually all decision-making power to states, cannot prioritize one project over another *in the national interest*. We have a funding system that encourages [study](#) after [study](#) of unfundable or unbuildable projects in places that refuse to commit their own resources. And we have a bureaucracy that, having never operated or constructed modern intercity rail, doesn't understand what it takes. This helter-skelter approach to transportation improvements is fundamentally incapable of supporting large-expenditure, [long-range projects](#) like high-speed rail.

This wasn't always the case. In 1956, [Congress approved](#) a significant increase in the federal gas tax, and with it a national plan for interstate highways. That plan, which included a steady stream of funding and a [clear map of national priorities](#), was [mostly completed](#) over the next three decades. Though implemented by states, highway alignments were chosen at the national level, with the intention of connecting the largest cities, regardless of political boundaries. Funding came almost entirely ([90 percent](#)) from the national government and was guaranteed as long as a route was on the national map. Physical requirements for roadways were [mandated at the national level](#) and universally applied. And construction was completed by state departments of transportation that were technically knowl-

edgeable, accustomed to building such public works, and able to make decisions about how to move forward.

The result was a system of roadways that most Americans rely on, many daily. The interstate system is unquestionably the nation's transportation lifeblood.

Yet Americans do not have the same perspective on the role of the federal government that they had when this highway system was initially funded. Trust in Washington [has declined](#) from more than 70 percent during the 1950s to less than 20 percent today. So although President Dwight Eisenhower [declared in 1955](#) that the federal government should “assume principal responsibility” for the highway system, the government's approach to a high-speed rail network has reflected the change in public thinking about Washington's place in transportation planning. This shift has reduced the federal government's ability to commit to a long-term plan and associated funding.



Recent [efforts to revive](#) this federal role have been seriously flawed. Take the Obama administration's [attempt at a national plan](#) of proposed inter-city rail investments in 2009.

For starters, the map's proposed routes were vague, a number of important connections [were not identified](#), and some routes appeared to have been chosen at random—simply the consequence of previous state studies with no national outlook. Funding had been dedicated through an [initial \\$8 billion](#) included in the stimulus bill, but there was certainly no guarantee that railways on that map would be built in the long term. The definition of *high-speed rail* was not applied universally; the administration proposed some links at 90 mph. and others at more than 250 mph, with no explanation for


why some would be slower than others. Finally, many of the states that were supposed to be implementing these projects were woefully unprepared for the task, having made few such investments in the past. None had the experience of building 200-mph electric railways to the international standard.

Such an approach to national transportation doesn't work. It leaves too many planning questions open to state decision making, and it fails to offer a financing source that actually produces the funds needed for intercity


rail. Far from fulfilling Eisenhower's mandate of assuming principal responsibility, the latest high-speed rail plan assumed too little.

But the need is still there. With falling automotive [vehicle miles traveled](#), [rising transit use](#), and booming city centers, we need new ways to connect our cities. More highways are not the answer, not only because they pollute the environment and destroy the neighborhoods they pass through, but also because they're relatively slow and become congested almost as soon as they're built. With a growing population, the country needs an expanded transportation system. The United States must invest in [clean, neighborhood-building, congestion-relieving](#) trains, but we cannot expect states to pick up the slack of an uncertain federal government.

It would be ridiculous to plan an intercity transportation system at the state level.



The planning and funding of the interstate highway system was premised on the fact that the travel needs of Americans occur irrespective of state lines. Indeed, the 50 largest metropolitan areas, representing more than half of the country's population, are located in 31 separate states, and 15 of them actually straddle state borders. Given this reality, it would be ridiculous to plan an intercity transportation system at the state level. California's high-speed rail progress—its proposed [San Francisco–Los Angeles line](#) remains the only truly fast-train project in the country—is the exception that proves the rule; that state's size makes it no example for the rest of the nation.

It's time for the United States to commit to national planning, funding, coordination, and prioritization of rail investment. Intercity transportation systems require active federal engagement to guarantee the development of routes that reflect national needs and national priorities. Yet without political consensus on the need to develop national goals and focus investments, high-speed rail will remain a pipe dream for decades to come. 

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